VOLUME XXVII JUNE, 1932 NUMBER 6

[FOUNDED IN 1906 AS THE AMERICAN QUARTERLY OF ROENTGENOLOGY]

JUN 27 1932

The AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

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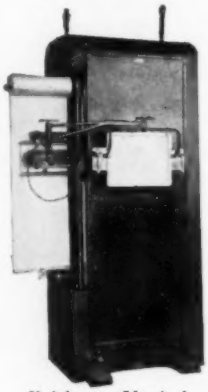

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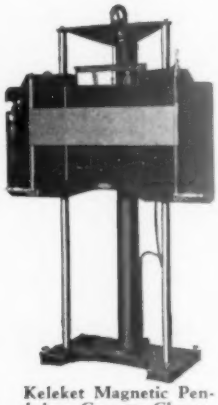

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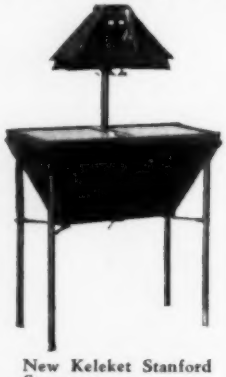

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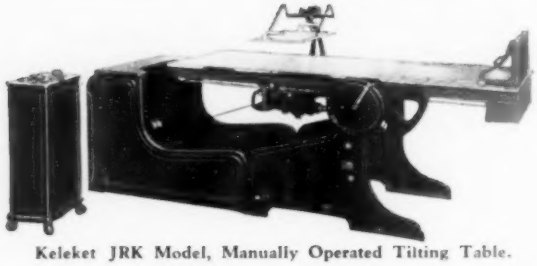

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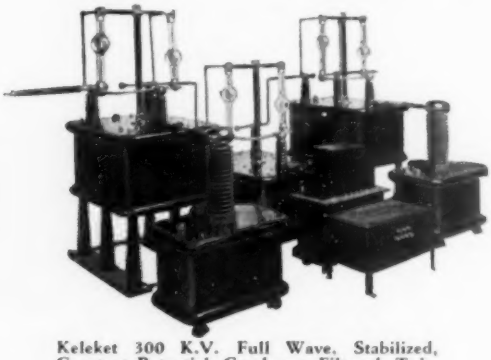

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THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

VOL. XXVII JUNE, 1932 No. 6

ABNORMALITIES OF THE VERTEBRAL BODY*

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THERE are certain fields in medicine and surgery which should be peculiarly the realm of the roentgenologist, for in these, by virtue of anatomic structure and nature of disease processes developing therein and type of injury to which they are subject, a greater amount of diagnostic information can be gained by roentgen study than by any other method. With this capacity and advantage for diagnosis, it is the responsibility of the roentgenologist to master every phase of disease or disorder involving such structures so that he will recognize and fully comprehend any deviation from the normal and thus qualify as a well-informed and helpful consultant. Such a field in roentgen practice is the study of the vertebral body, and it is the purpose of this paper to enumerate the various deviations from the normal which occur in this structure, describe their development and discuss their clinical importance, giving special attention to the medicolegal aspects involved.

The relatively recent technique for spine examinations which permits the demonstration of the vertebral body structure in excellent detail, more especially by means of the lateral projection, has added greatly to the opportunities of the roentgenologist for rendering valuable and unique diagnostic aid. The difficulties we in our organization have experienced in classifying many distortions and deformities of the vertebral bodies revealed by films taken with the improved technique, and the frequent controversies in practice and court, have stimulated us to more intensive study of these conditions. While many of the observed departures from the normal have academic or passing interest only, others are of unusual importance. In this latter group fall especially the variations discovered in the examination made for changes incident to trauma or secondary to certain occupations.

For convenience in presentation, the following grouping of vertebral body abnormalities will be followed:

1. Chronologic changes or normal variations peculiar to certain ages.
2. Developmental anomalies.
3. Changes associated with nutritional disorders.
4. Changes resulting from trauma.
   (a) Primary or recent.
   (b) Secondary or late.
5. Postural or occupational changes.
6. Inflammatory changes.
   (a) Tuberculosis.
   (b) Syphilis.
   (c) Osteomyelitis.
   (d) Epiphysitis and osteochondritis.
   (e) Osteoarthritis.
7. Distortion of the bodies secondary to intervertebral disc abnormalities.

* Read at the Thirty-second Annual Meeting, American Roentgen Ray Society, Atlantic City, N. J., Sept. 22–25, 1931.

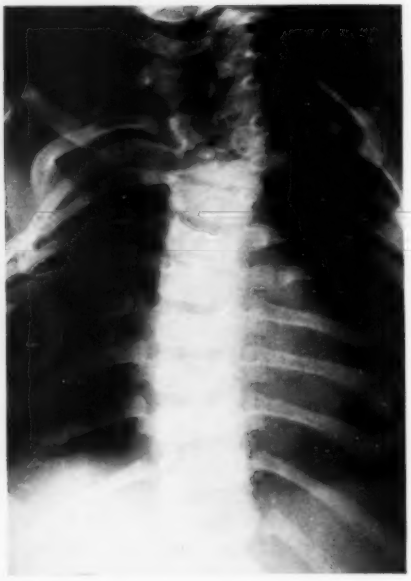

Fig. 1. Anomaly of the morphologic type, confined to the cervical and upper thoracic regions.

Fig. 2. Anomaly of the morphologic type, all spinal levels involved.

Fig. 3. Congenital defect in the upper thoracic bodies, anteroposterior projection.

Fig. 4. Same as Figure 3, lateral projection. Condition diagnosed as fracture and patient so treated until the lesion was properly classified. Note the absence of irritative or reparative changes.

Fig. 5. Congenital defect in the intervertebral disc between the fourth and fifth cervical segments. This defect was classified as a double compression fracture and was so treated. The condition was held traumatic by the Compensation Board.

Fig. 6. Two defective intervertebral cartilages, with fusion of the three bodies, the so-called "block vertebrae."

8. Deformities due to constitutional disease.
   (a) Parathyroid.
   (b) Disturbance in lipoid metabolism.
9. Deformities due to malignancy.
   (a) Primary.
   (b) Metastatic.

1. CHRONOLOGIC CHANGES OR NORMAL VARIATIONS PECULIAR TO CERTAIN AGES

The contour of the vertebral body, as shown in the profile, in infancy and early childhood is oval or egg-shaped, with intervertebral spacing of unusual height. Occasionally, however, the bodies may be notched anteriorly in their midportion, this representing the entrance of the nutrient vessels.

In the pre-adolescent period, the contour of the vertebral body is octagonal, with less disproportion between the height of the body and the height of the disc.

During the period of adolescence, the contour of the body is again changed by the appearance and development of new centers of ossification, the so-called epiphyses. In lateral roentgenograms, the epiphyses present themselves as separate triangular bone fragments at the inferior and superior angles of the vertebral bodies.

In the post-adolescent period, there is complete ossification of the epiphyses and the body assumes the typical rectangular form.

At the approach of senility, due to demineralization and secondary pressure from the intervertebral cartilages, the bodies assume a biconcave form.

Not infrequently there are localized or limited abnormalities in the contour of the vertebral bodies in adult life resulting from calcification in the ligaments of the spine, which represent a normal physiologic process but which are often confused with arthritic changes.

This particular change assumes unusual importance when found in cases examined for evidence of injury, for disease changes or other basis for disturbed function or varying degrees of disability. The usual classification of such changes—arthritis—is a serious error, both on account of the mental harm done the patient and the injection into the case, from the legal standpoint, of the question of traumatic influence on the process.

2. DEVELOPMENTAL ANOMALIES

In order to comprehend the various anomalies seen in the spine, a knowledge of the embryologic development of the vertebral column is necessary. First, the blastodermic tissue becomes differentiated into the mesoderm, entoderm and ectoderm. The first anlage of the spine is a longitudinal column of entodermal cells called the notochord, which forms beneath the neural groove (later the neural canal). Then, paralleling this notochord are longitudinal groups of mesodermal cells and the paraxial mesoblasts. These two paraxial masses undergo segmentation, producing about thirty-seven bodies called somites. Each somite has a principal mass of dense substances, later muscle, within which is a collection of looser tissues. These looser tissues break through and grow toward the notochord, being now called sclerotomes. The right and left sclerotomes grow toward each other around the notochord, being separated by a membrane continuous with the perichordal sheath. The sclerotomes become differentiated into two parts, the less dense cranial part, anlage of the intervertebral disc, and a more dense caudal portion which becomes the primitive vertebra or scleromere. The scleromeres become transformed into dense cartilage, there being two centers of chondrification, which are at first separated by a septum but which later break through and fuse. The notochord becomes constricted in the centers of the bodies and expanded in the region of the discs, eventually segmenting entirely, the segments forming the nucleus pulposus of the discs.

In the cartilaginous body, one center of ossification develops to form the bulk of the anterior portion of the body and the

remaining posterior portion develops by extension of the ossification from the two primary centers of the arches. (Occasionally there are two anterior or main centers of ossification corresponding to the two centers of chondrification. These have been observed in adults.)

According to Hanson,[6] in the newborn the vertebral body shows three zones of osseous tissue, a middle transverse zone of

Fig. 7. Healed rickets.

Fig. 8. Familial osteochondrodystrophy, anteroposterior projection.

Fig. 9. Same as Figure 8, lateral projection.

Fig. 10. Familial osteochondrodystrophy in a somewhat older patient than shown in Figures 8 and 9.

Fig. 11. Fracture of the lateral process, first lumbar vertebra, with no frank evidence of injury to the vertebral body.

lessened density which is fully formed cancellous bone, and two layers, one superior and one inferior, which are more dense and represent ossifying cartilage. The central, more vascular, layer has large canals for blood vessels which are evident on roentgenograms of all infants and which may persist to adult life. The central layer is smaller than the others, giving the appearance of a depression when observed in profile.

The center for the anterior part of the body unites with that of the posterior part at about four to six years of age.

Secondary centers of ossification, the so-called epiphyses, appear in the chondral superior and inferior portions of the discs as early as the sixth or as late as the seventeenth year. Complete fusion of these centers with the main body occurs at about the twentieth year.

Thus the morphologic anomalies of the spine usually described in roentgen literature as intercalation or excalation are the result of imperfect segmentation or of variation in the ossification centers. The variations in the ossification centers may be numerical or they may be numerically correct but with the grouping irregular. Consequently, the vertebral segment may develop without a body or with a hemibody, or there may be fusion of two bodies, either completely or unilaterally, or there may be cross fusion to correspond to the irregular grouping of the ossification centers.

A less common anomaly is the faulty development following the sclerotome stage when there is more or less complete absence of the intervertebral disc with the bodies variously fused, the so-called "block vertebra." This peculiarity in development is observed most frequently at the cervical level, occasionally at the thoracic level, but has not been seen by us at the lumbar level.

It must be obvious that a comprehensive knowledge of the embryologic development of the spine facilitates the recognition of these anomalies; on the other hand, a lack of such knowledge will lead to misinterpretations in which the anomalies may be considered as resulting from trauma or a destructive process. In this respect, extreme care must be taken in arriving at a differential diagnosis of such lesions in the mid-thoracic region where a clear visualization of the spinal structures is difficult because of the superimposition of the shadows of the shoulders.

Although it is beyond the scope of this paper, an anomaly infrequently encountered may be briefly mentioned which is not associated with any definite deformity in the contour of the vertebral body itself, but which results from a defect of the centers forming the neural arch and the body posteriorly. This is the defect in the fifth lumbar vertebra which results in an extreme spondylolisthesis. Such a lesion has unusual importance since its presence may be unsuspected and its recognition or demonstration will await roentgen examination for evidence of injury.

If added proof is demanded supporting a diagnosis of a congenital lesion against a pathologic or traumatic one, it can be pointed out that in the case of a congenital condition no reparative or irritative changes are present, but where trauma is a factor in the deformity, either or both of the latter changes will be demonstrated.

3. Changes Associated with Nutritional Disorders

(a) *Rickets.* There is no deformity of the body characteristic of rickets. In this disease, the spinal segments are not well demonstrated on the films because of their low lime content. Usually in the active or first stage of the disease, the body is not definitely distorted in outline, but its margins have a "frayed" appearance. Later on, in the second stage, there are observed coarse longitudinal striations, with increasing density, and in the third stage the body shows marginal "white lines," giving the appearance of a double body, or a body within a body. At no time is there any collapse of the bodies and neither is there tendency to fusion.

Fig. 12. Same as Figure 11, six months later. Definite irritative and reparative changes, involving the second and third lumbar bodies on the injured side. This finding justified the claim for prolonged period of disability.

Fig. 13. Fracture of the body of the third lumbar with distorted cartilage superiorly. At this time the defendant petitioned that compensation be stopped, which was justly denied.

Fig. 14. Same as Figure 13, ten months later. Progressive healing, but still basis for disturbed function. Compensation continued.

Fig. 15. Same as Figure 14, ten months later. Healing complete without definite basis for disturbed function. Patient should be able to resume his former occupation, which was not strenuous.

Fig. 16. Incomplete healing of compression fracture at the upper lumbar level with thinning of the intervertebral cartilage, which would be a basis for disturbed function.

Fig. 17. Completely united compression fracture without basis for disturbed function. Irritative changes absent.

The secondary deformities are those resulting from general pressure incident to the weight-bearing function of the spine.

(b) *Osteomalacia.* In osteomalacias, especially the hunger type which was frequently observed in Germany shortly following the war, there is noted a deformity of the vertebral bodies manifesting itself in a biconcave lenticular aspect. This is the result of pressure from swollen intervertebral cartilages on the weakened bodies.

(c) *Familial Osteochondrodystrophy.* While this condition has as an etiological basis a probable disturbance in the endocrine glands and not a nutritional disorder, the changes in the vertebral bodies will be described under this grouping.

In this condition the spinal bodies show marked variations in size and are of varied shapes, the most common outline being irregularly ovoid. The lime content is well maintained and the detailed structure approaches the normal. The intervertebral spacing is increased, but the body contour is not apparently influenced by cartilage pressure.

Generally it can be said that any process which interferes with the strength of the vertebral body will result in disturbed structure and contour, since the bodies will mold to conform with posture, position and pressure.

The practical importance of the recognition of rachitic and other nutritional changes of the spine is the immediate institution of treatment to prevent scoliosis. This should be done before the important structural changes take place, for scoliosis is an early expression of softening and increased pliability of the spine.

4. CHANGES RESULTING FROM TRAUMA

No attempt will be made to include a full discussion of fractures of the vertebral body, but certain points in differential diagnosis will be considered in fractures not well defined, and attention will be given to the question of treatment of certain types of the more extensive injuries.

The recognition of a fracture of the vertebral body may be attended with considerable difficulty, especially when the examination is made several weeks or more following injury. The demonstration of a wedge-shaped deformity is not conclusive proof of fracture and certain changes in the structure and outline of the body must also be present to justify such a diagnosis. A knowledge of the variation in gross and detailed structure of the vertebral body at various levels is necessary if changes are to be interpreted correctly, and one should be familiar with the various types of fracture occurring at the several levels.

At the cervical level, fractures of the vertebral body are relatively rare, severe injuries to this region usually resulting in dislocation. When fractures do occur, they, as a rule, are complicating a dislocation and the common lesion is a separation of a relatively small triangular fragment at an upper anterior angle of the body of the dislocated or adjacent segment, and not the usual compression or egg-shell fracture. However, true compression fractures do occur and in this event the appearance of the fractured body does not vary from that observed in similar fractures at lower levels. A very common distortion of the lower cervical segments often interpreted as fracture is the wedge-shaped formation of the fifth, sixth or seventh body, which change is associated with narrowed intervertebral discs and osteophytic or hypertrophic changes at the anterior angles of the distorted bodies. This condition to an extreme degree is often an incidental finding and generally has no clinical or diagnostic significance.

Owing to the protection offered the thoracic bodies by the peculiar anatomy of the spine in this area which gives them relative rigidity, fractures at this level are comparatively rare, with the exception of the lower segments, which approach the lumbar formation. Compression fractures do occur, however, and their recognition is especially difficult because in this region in many patients the bodies are wedge-shaped, the deformity representing a de-

Fig. 18. First or anterior peripheral involvement of the vertebral body in tuberculous infection.

Fig. 19. Tuberculosis of the body of the second lumbar segment with the central type of localization. Note chronic bone proliferation and bony new growth.

Fig. 20. Same as Figure 19, lateral view, showing more graphically the central destruction of the body.

Fig. 21. Early tuberculosis of the peripheral type with involvement of the vertebral body margins and intervertebral cartilage.

Fig. 22. More advanced stage of the third localization of infection.

Fig. 23. Syphilis of the spine.

velopmental kyphosis or a postural deformity. As stated above, the presence of a wedge-shaped body is not evidence of fracture and before such a diagnosis can be made, there must be demonstrated certain variations in bone structure, texture and outline. The most common of these is bone condensation, which usually appears at the upper margin of the involved body, and this condensation is not necessarily associated with disturbance in outline. In the more severe fractures, in addition to the slight wedging and bone condensation, there is observed disturbance in outline, especially at the anterior margin of the body, due to impaction. The appearance of this does not vary from slight impactions noted in the case of similar fractures of the long bones.

In the event that the examination for fracture is made several months following the injury, there are secondary bone changes present which indicate that the wedge-shaped deformity is the result of fracture. Thus, associated with the change in the general contour and texture of the vertebral body, there will be observed hypertrophic bone changes. When the new bone formation occurs at the body margins and projects anteriorly, it can be concluded that this represents the ordinary hypertrophic spine. If the bone formation, however, extends upward tending to bridge the intervertebral spacing, then it may be concluded that this bony overgrowth is secondary to a fracture of the vertebral body and injury to the adjacent soft tissues and represents irritative or reparative processes.

The early recognition and determination of the degree of deformity of a compression fracture of the vertebral body is important because of the advantages to be gained by early and proper treatment of such fractures. Formerly compression fractures were not treated actively, but of late many of the vertebral body deformities can be overcome by manipulation, forcible extension, traction and countertraction, as described by Dunlop and Parker.[4] This recognition of the type and extent of vertebral body fracture and the institution of appropriate treatment in an attempt to restore the normal contour of the body is of great importance in industrial surgical practice. In untreated or badly treated compression fractures, a large percentage of patients are eventually classed as totally disabled, whereas under the more modern treatment full function and capacity are restored in the majority of cases.

Frequently it becomes necessary in compensation cases to determine if a fracture has healed without a basis for symptoms or disturbed function. From a study of a considerable series, with relatively frequent roentgen studies over a long period, we have determined, or concluded, that in the absence of irritative or reparative changes involving the body and in the presence of a preserved intervertebral cartilage and its nucleus pulposus, it can be assumed that healing is complete and that the patient should be symptom-free. This applies, of course, to the uncomplicated compression fracture of the vertebral body.

6. INFLAMMATORY CHANGES

(a) *Tuberculosis*. The deformity of the vertebral body induced by tuberculosis will depend upon the site and stage of the infection. The work of Koenig[8] established that there are three zones of arterial distribution in the vertebral bodies and these correspond with the three distinct types of localization of tuberculosis: the first, the anterior peripheral; the second, the central, and the third, those in which the vessels take an upward and downward course and supply the margins and the epiphyses of the vertebrae.

In the case where the infection begins in the first or anterior peripheral distribution, the destruction of the vertebral body occurs anteriorly, and a collapse follows with the formation of a wedge-shaped deformity. In the case of infection by way of the central blood distribution, there occurs a defect in the center of the vertebral body which enlarges until the body weight re-

Fig. 24. Simple early stage localized epiphysitis.

Fig. 25. Simple localized epiphysitis, late stage.

Fig. 26. Early stage of osteochondritis deformans dorsalis juvenilis. Develops into a dorsum rotundum.

Fig. 27. Late stage of dorsum rotundum.

Fig. 28. Pathologic intervertebral cartilages with narrowing of the spaces. Body deformity due to softening and limited defects in the bodies due to nucleus pulposus pressure, active stage.

Fig. 29. Late stage of the same process as shown in Figure 28. Note calcification in the nucleus pulposus.

sults in collapse and gives this deformity. In the third type, where the blood distribution is to the margins of the bodies, the disturbance in body outline is associated with and accompanied by destruction of the intervertebral cartilage.

In the later stages of tuberculosis, contrary to the usually accepted view, there are bone regeneration and overgrowth which produce irregularities simulating old fracture or other healed pathologic changes.

(b) *Syphilis.* The deformity of the vertebral body in syphilis is not characteristic, but there is usually noted localized destruction from gumma, or, in the later stages, a marked increase in the lime content of the body, variation in contour and extensive bony over-growth at the vertebral margins. There are additional changes in body structure and contour, usually secondary to the involvement of the intervertebral disc in the luetic process. In this instance, the disturbance in structure is largely peripheral, the appearance being that observed in syphilis of other joints.

(c) *Osteomyelitis.* Osteomyelitis of the vertebral body is a relatively rare occurrence, and there is nothing in the deformity characteristic of this destructive process.

(d) *Epiphysitis and Osteochondritis.* According to Buchman,[1] vertebral epiphysitis is a term first used by Delahaye,[3] in 1924, in describing 3 cases of painful back in patients of adolescent age. In these patients there was no evident deformity of the vertebral bodies and no disturbance in the vertebral contour. Delahaye also described a second group of adolescents in which the painful back was associated with kyphosis and in which roentgen studies of the spine revealed deformed vertebral bodies with abnormal epiphyses and intervertebral cartilages. He called this latter condition "the painful kyphosis of adolescence."

Whitman,[14] in his 1927 edition of "A Treatise on Orthopaedic Surgery," dismissed the subject of vertebral epiphysitis with a few references from the literature, a brief description of changes in the spine structure demonstrable by the roentgen ray, a short description of symptoms and a suggestion as to treatment.

Steindler,[13] however, in his 1929 edition of "Diseases and Deformities of the Spine and Thorax," treats the subject more comprehensively. It is apparent in reading his text that he obtained his knowledge of this condition by familiarizing himself with the work of Scheuermann[11] and Delahaye and by his acquaintance with the work of Buchman.

For some time in our practice, both hospital and private, we have had occasion to study the spines of several patients referred with a clinical diagnosis of vertebral epiphysitis. In these cases certain roentgen changes were observed which we grouped, for lack of information, under the general heading of "signs of epiphyseal disease." Later, more careful and detailed study convinced us that the whole subject was a rather complicated one and that the multiplicity of changes could not be associated with one process. As the subject was investigated further, it became apparent that there was much in the literature pertaining to the subject which was contradictory. For instance, Schmorl[12] and Polgár[10] contend that the condition described by others as vertebral epiphysitis, a terminology they do not approve, is to be explained by changes induced either by trauma or changes incident to a congenital anomaly of the vertebral cartilage, this cartilaginous change being secondary to or associated with a disturbance in the nucleus pulposus and cartilaginous plates. This group of workers prefer to use the term "juvenile kyphosis." Their theory is that these changes, which have been described as indicating the presence of an epiphysitis, are really pathologic changes involving the intervertebral cartilages, with secondary changes in the adjacent margins of the vertebral bodies. Thus, in discussing osteochondritis of the spine, the pathologic changes really take place in the superior and inferior cartilaginous plates of the intervertebral disc. Only on this as-

Fig. 30. Late stage of osteoarthritis. Patients with this condition are often symptom-free.

Fig. 31. Defects in the vertebral bodies superiorly which represent early pressure defects from nucleus pulposus rupture.

Fig. 32. Disturbed vertebral body structure resulting from chronic nucleus pulposus pressure.

Fig. 33. Deformity of the vertebral body with generalized demineralization typical of active hyperparathyroidism.

Fig. 34. Multiple vertebral body deformities characteristic of parathyroid hyperfunction following parathyroidectomy, with redeposition of lime.

Fig. 35. Active stage of parathyroid disease. The bodies are demineralized and show concave deformity characteristic of pressure from enlarged intervertebral cartilage. In this case the nucleus pulposus is not released.

sumption can the widespread changes in the vertebral outline be explained. It becomes evident that these changes can be divided into three groups:

(1) Simple epiphysitis in which the disease is localized to the epiphysis alone and the adjacent margins of the bodies, with normal general outline and relation of the bodies maintained.

It should be stated at this time that there is no agreement that the first grouping is observed, although clinical and roentgenologic studies indicate that the condition exists and can be readily recognized clinically and observed roentgenographically. Schmorl, whose work has done so much to stimulate interest in the study of the spine, does not admit the presence of epiphyses, stating that the structures usually described as epiphyses really represent a marginal continuation of the cartilage plates undergoing ossification. These ossifying cartilaginous margins constitute the so-called rim bands which in time entirely fuse with the vertebral bodies, completing the development of these structures. Junghanns,[7] in supporting Schmorl's view, asserts that the small triangular bone structures lying adjacent to the vertebral body angles, which are diagnosed as epiphyses, in certain cases represent detached spicules due to trauma or in others anomalies or calcification within the annulus fibrosus structure of the intervertebral cartilage or disc.

The roentgen appearance of the lesion in the condition of vertebral epiphysitis is that of variations in size and structure of the bony portion of the epiphysis and variations in lime content, with more or less destruction of the adjacent structures, and, in addition, changes associated with reaction resulting in loss of tissue detail in the region of the process.

(2) Osteochondritis. In this group no epiphyseal abnormality is observed, the changes being confined to the cartilaginous plates and adjacent margins of the vertebral bodies. In this group, the roentgen appearance depends upon the stage and extent of the disease, and in the early and active cases the upper or lower vertebral margins are thinned and show a wavy appearance or irregularities resulting from the pressure of the diseased cartilage plates. In the more advanced and later stages, in addition to these changes, definite defects may occur in the vertebral bodies, due to localized destruction from pressure from the released nucleus pulposus.

(3) In this group there are pathologic changes of both the epiphyses and the intervertebral cartilages. They are usually designated as juvenile or adolescent kyphosis, or osteochondritis deformans dorsalis juvenilis. The roentgen appearance in these cases is a combination of the two types of change. Patients suffering from this form of spinal disease are usually large for their age, muscular and inclined to adiposity. They develop a stooped posture, the so-called round shoulders or dorsum rotundum. In addition, they exhibit various forms and degrees of scoliosis.

The significance of these processes lies not in their immediate recognition and classification, although this is important from the standpoint of institution of proper treatment, but in the fact that many abnormalities of the spine discovered in adult life can be explained by the general relation to such processes during adolescence. In medicolegal practice, a knowledge of the development of childhood deformities is most important.

(e) *Osteoarthritis*. The deformities of the vertebral bodies associated with osteoarthritis resemble, in a general way, those associated with senile and other forms of hypertrophic changes, but in this disease they are more extensive both in distribution and locality. There is no tendency to fusion of the bodies directly, but they do become united by the new bone formation, bridging the intervertebral spacing. This is due, according to Steindler, to the irregular osteoarthritic overgrowth. However, in the more advanced stages, owing to a developing osteoporosis, the bodies flatten in the vertical direction while their transverse diameter becomes increased.

Fig. 36. Extensive deformity of the vertebral bodies associated with late hyperparathyroidism.

Fig. 37. Spondylitis deformans of the Struempell-Marie type possibly belonging to the ankylosing polyarthritis of Oppel, anteroposterior projection.

Fig. 38. Same as Figure 37, lateral view.

Fig. 39. Deformity of the spine characteristic of Paget's disease.

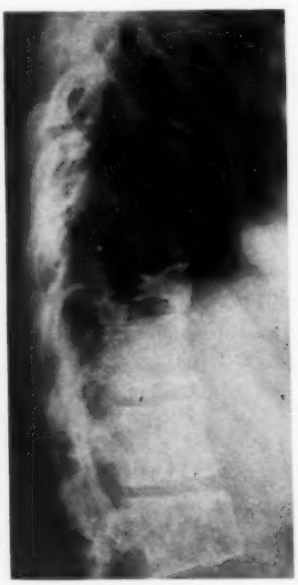

Fig. 40. Distortion of vertebral bodies due to metastatic invasion.

Fig. 41. Disturbed vertebral body structure showing healed metastatic carcinomatous involvement. Patient had received lead therapy in addition to irradiation.

5. POSTURAL OR OCCUPATIONAL CHANGES

Lane,[9] in his book entitled "Operative Treatment of Fractures," has a chapter on "The changes which the skeleton undergoes from the habitual assumption of attitudes of activity or of rest." It is apparent, then, that even before the days of the roentgen ray, well-informed medical men knew that variations in bone outline, structure and contour did not always represent disease or acute injury, but were variations due to the so-called stress and strain, or "wear and tear," that is, that variations resulted from the adjustment of the body to meet unusual demands.

Thus, in the early stages of spinal disalignment, whether it be scoliosis, lordosis or kyphosis, the curvature is not associated with or dependent upon distorted vertebral body contour. But in time a bone change is observed, the constant and long-continued pressure resulting in various shapes, depending on the direction and point of application of the pressure. The most common distortion is the wedging of the midthoracic segments in the varying degrees of kyphosis.

In certain occupations, where unusual position is required or where one particular set of muscles is used excessively, similar bone adjustments are observed.

It was also observed that there were other skeletal changes associated with advancing years.

It is now recognized that the various deposits of lime in the vertebral ligaments which distort the body angles represent a natural or physiologic process and correspond to such changes in other tissues.

This is quite in contrast to the present tendency of poorly informed roentgenologists or others of the medical profession to classify the hypertrophic changes in connection with the spines of adults as hypertrophic or traumatic arthritis, despite numerous publications, especially that of Cushway and Maier,[2] in which it is stated that 90 per cent of men beyond the age of forty have these changes. It is a frequent experience to hear testimony in court that such changes represent a definite arthritis or changes incident to trauma, or that these changes are productive of symptoms and are sufficient to produce disability or disturbed function.

7. DEFORMITIES SECONDARY TO INTERVERTEBRAL DISC CHANGES

In reviewing Gray's[5] Anatomy, edition of 1901, Figure 152, which is a vertical section of two vertebrae, was found to be most illuminating. This cut shows the body of a vertebra with the blood vessel spaces (the so-called venae basis vertebrae), and the intervertebral substance with the nucleus pulposus which is given the name in this cut of pulpy center. If roentgenologists had been familiar with this illustration, they might have anticipated the work done by Schmorl in which he demonstrated that certain defects in the periphery of the vertebral bodies adjacent to the intervertebral cartilage were secondary to pressure changes from this pulpy center, or what is now known as the nucleus pulposus. When the bodies are shown in the lateral projection, there are observed more or less rounded areas of bone thinning, with a limited margin or zone of increased bone density. These defects are usually a little posterior to the midline, are of varying size, usually about 1 to 1.5 cm. in diameter, and they may or may not be associated with symptoms.

It has been shown by Schmorl that these defects may also be the result of developmental anomalies of the spine, of senile changes or, finally, of pathologic processes (such as tuberculosis, purulent osteomyelitis, osteoclastic cancer metastases, etc.).

Of surgical interest is the possible occurrence of a partial or complete displacement of the nucleus pulposus into the spinal canal. Two cases of paralysis following spine injury without evident fracture were operated on and the nucleus pulposus removed from the canal, with the return of function.

Another deformity of the vertebral body secondary to intervertebral disc disturb-

ance is the deformity known as the fish spine. In these cases, the entire intervertebral disc becomes thickened and enlarged, usually due to increased fluid content, and this expansion brings about pressure on the bodies, with resulting concave formation at both inferior and superior borders.

8. CHANGES INCIDENT TO CONSTITUTIONAL DISEASE

The function of the bodies of the spine, aside from protection to the cord, is weight-bearing. If there is any process which brings about destruction of the cortical portion of the bodies or of the plates, or softens the cancellous portion of the body, it is evident that distortion will result from pressure. The deformity resulting from such a pathologic process is peculiar in that the flattening is uniform, in contradistinction to the deformity which follows fracture, in which event there is wedge-shaped formation with the body narrowed anteriorly. In hyperfunction of the parathyroid glands, in which there is a disturbance in calcium metabolism, there is usually a widespread demineralization involving all of the spine and other skeletal structures, but in addition there will be one or more vertebral bodies, more especially at the thoracic level, where there is a uniform narrowing with the depth of the body constant both anteriorly and posteriorly.

A somewhat similar deformity of the vertebral body is observed in cases of disturbance in lipoid metabolism, but in these cases the patients are young and the rest of the spine does not show the uniform demineralization.

9. DEFORMITIES DUE TO MALIGNANCY

The malignant tumors involving the vertebral body may be generally divided into two groups: (a) primary and (b) secondary tumors.

(a) The primary tumors occur only rarely. Chief among them are osteogenic sarcoma, myeloma and giant cell tumor. This latter, although usually classified as benign, presents in its location in the spinal column, because of the secondary changes produced, a very malignant course and

FIG. 42. Disturbed vertebral body structure resulting from metastatic malignant invasion from prostatic tumor.

FIG. 43. Deformity associated with disturbed lipoid metabolism.

FIG. 44. Vertebra plana, etiologic factor not determined.

therefore should clinically be included in the group of malignant tumors.

(b) The secondary tumors form the bulk of the vertebral neoplasms. They are chiefly observed in hypernephroma and carcinomas of the breast, thyroid and prostate, but may occur also in other types of carcinomas and occasionally in sarcoma, Ewing's tumor and endothelioma. Pathologically these tumors lead, in the majority of instances, to a destructive process appearing in the roentgenograms in the form of areas of rarefaction or bony defects. Later, with progress of the disease, a collapse of the vertebral body, with secondary changes, occurs. In a limited number of cases, more especially in carcinoma of the prostate, an osteoblastic process with increase in the density of the vertebral body (the so-called ivory vertebra) is observed. Here the contour of the vertebral body as a rule is preserved intact.

It may be mentioned here that the intravenous administration of colloidal lead followed by the application of deep roentgen therapy often results in a marked regeneration of the bone within the areas involved by the malignant process so that roentgenographically the vertebral bodies often assume a density which is increased above the normal.

We think enough has been shown to indicate that the subject is a comprehensive one, that there are problems still unsettled and that the vital aspect of the question is the recognition of early changes so that corrective measures can be instituted before permanent damage is done or the stage of therapeutic aid has passed.

It should be emphasized again that classification of vertebral body deformities is often most difficult and even at times impossible, so that in our experience some cases must be reported as indeterminate.*

* For discussion see page 834.

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INTRINSIC CIRCULATION OF THE VERTEBRAL BODY

WITH ROENTGENOLOGIC CONSIDERATIONS*

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IN AN attempt to understand an unusual disease process of the lumbar vertebrae of a boy, a study of the intrinsic circulation of the human vertebral body was undertaken. Reference to standard works on anatomy and a review of the literature failed to inform us adequately as to the normal circulation and it was necessary to resort to original investigation. The preliminary results of this investigation were given elsewhere.[1] Here an attempt is made to correlate these findings with a number of the more common disease processes affecting the vertebral bodies, as shown in lateral roentgenograms.

For clarity it is essential that the course of the blood vessels leading to and from the vertebral bodies be reviewed.

Arterial Supply. The bodies of the lumbar vertebrae in man receive arterial blood

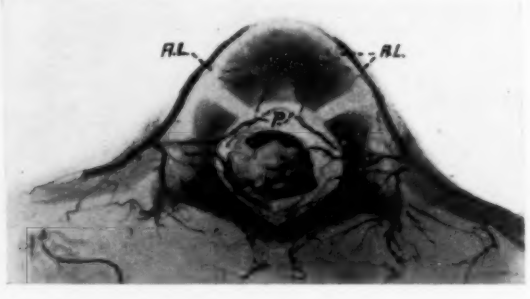

FIG. 1. Enlarged roentgenogram of twelfth thoracic vertebra of horizontal section, still-born infant injected with barium mixture. *A. L.*—Anterolateral arteries; *P.*—Posterior arteries. (Course of arteries within body retouched with India ink.)

by way of the lumbar arteries and their branches. The lumbar arteries arise in pairs from the posterior walls of the abdominal aorta and pass posteriorly. After the lumbar arteries penetrate the anterior muscle groups, the dorsal branches (rami dorsali) arise and continue posteriorly in the hori-

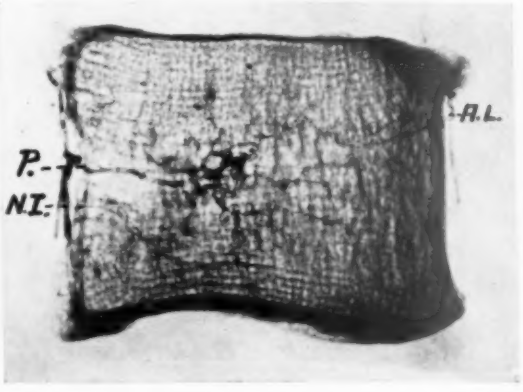

FIG. 2. Roentgenogram of thin vertical section of mid-portion of second lumbar vertebra, negro, male, aged twenty-three, who died of pneumonia. Injection of abdominal aorta with barium mixture. *P.*—One of the two posterior arteries; *N. I.*—Small nutrient artery; *A. L.*—Anterolateral artery.

zontal plane, one on either side of the vertebral body, just above the midline. These arteries lie in direct contact with a portion of the anterior and the entire lateral wall of the vertebral body.

From the medial surface of the rami dorsali, as they lie in contact with the vertebral body, arise branches which penetrate directly into the bone. The number of such branches varies but there commonly are present one main anterolateral and a smaller lateral branch on either side. These arteries may be followed well into the middle of the vertebral body before they divide and lose their identity (Fig. 1).

In the region of the intervertebral foramen the ramus dorsalis divides into a spinal branch (ramus spinalis) and a muscular

[1] Cystic disease of a vertebra with its relationship to the arterial supply. Read before the Forty-fifth Annual Session of the American Orthopaedic Association, Memphis, Tenn., April 16, 1931.

* From the Department of Orthopedic Surgery, Graduate School of Medicine, and the Department of Roentgenology, School of Medicine, University of Pennsylvania, Philadelphia. Read at the Thirty-second Annual Meeting, American Roentgen Ray Society, Atlantic City, N.J., Sept. 22–25, 1931.

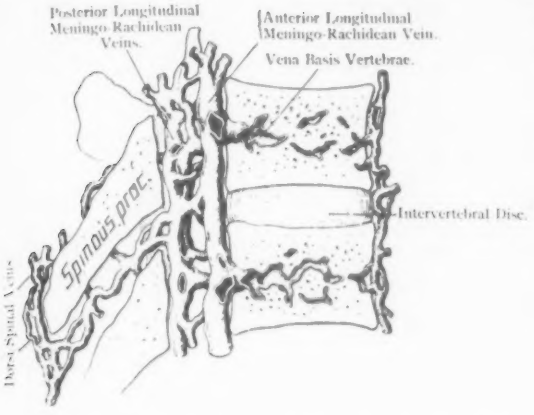

Fig. 3. Diagrammatic drawing of venous plexus within neural canal (Deaver's Surgical Anatomy).

branch which supplies the muscles and skin of the back.

The ramus spinalis passes through the spinal foramen into the spinal canal to anastomose with its fellows and contribute to the (paired) anterior and posterior spinal arteries. From each of the anterior spinal arteries a medial branch arises and passes medially along the posterior wall of the vertebral body. These two branches penetrate the vertebral body in the midline, at a point just above the exit of the veins. These penetrating posterior arteries may be followed well into the central substance of the vertebral body before they divide (Fig. 2). Smaller pairs of nutrient arteries penetrate the posterior vertebral body wall at points above and below the level of those just described. These small nutrient arteries arise either directly from the anterior spinal arteries or their medial branches (Fig. 2). From the size of the arteries to the vertebral bodies it can be inferred that the volume flow of blood is relatively small.

Venous Drainage. Each lumbar vertebral body is drained by four main venous trunks. Two leave the body, one on either side, from an anterolateral position at a level just above the midline. Two emerge as paired vessels from the bony foramen in the center of the posterior vertebral body wall. The two posterior veins (basi-vertebral veins) empty at once into the anterior longitudinal meningorrachidian veins of the posterior external plexus. Direct connection is made with the corresponding lumbar veins by means of the spinal rami branches of the same. The lumbar veins pass anteriorly in pairs, one on either side of the vertebral body accompanying the corresponding artery and lying above it. The two anterolateral veins from the vertebral body empty directly into the lumbar veins. The lumbar veins pass anteriorly and empty into the vena cava but before doing so are united by vertical branches with their companion veins and with the azygos or hemiazygos systems.

A comparison of the diameters of the veins

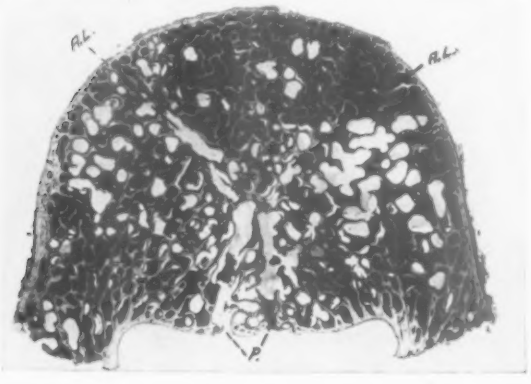

Fig. 4. Photograph of a horizontal serial section of third lumbar vertebra of same case as Figure 2. Point of emergence of the two (*P.*) posterior veins, their central mergence and beginning of (*A. L.*) anterolateral veins clearly shown as empty spaces.

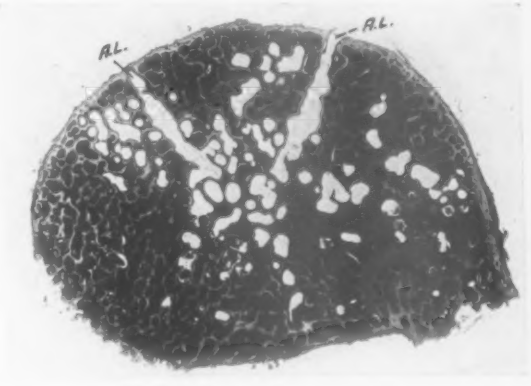

Fig. 5. Photograph of a horizontal serial section at higher level than Figure 4, showing points of emergence of the two (*A. L.*) anterolateral veins.

leaving the vertebral bodies with those of the arteries entering shows an unexpected relationship between the two. The diameters of the veins are much greater than those of the arteries. In consequence, it must follow that the vertebral bodies contain a large volume of blood but that the rate of flow of this blood within the body is comparatively sluggish.

From the standpoint of the dynamics of circulation, it is interesting to note that the lumbar veins passing horizontally are in direct communication with three great longitudinal or vertical venous systems: (1) posteriorly with the posterior external

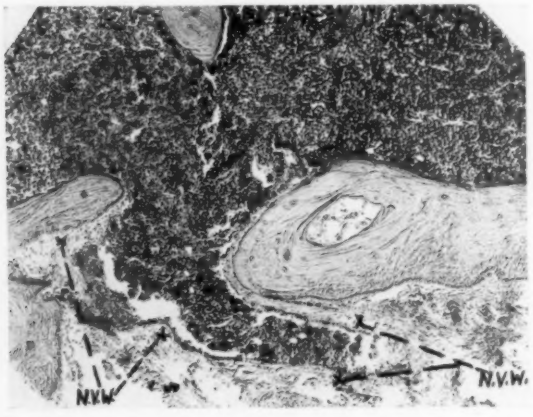

FIG. 6. Photomicrograph of a histological section of second lumbar vertebra of female negro, aged twenty, who died of pneumonia. Section at level of emergence of one anterolateral vein. Note normal vein wall (*N. V. W.*) of that portion lying outside of the vertebral body and the loss of normal vein wall within vertebral body, together with close approximation of wall of venous space to bone trabeculae.

venous plexus which extends vertically within the spinal canal external to the spinal cord membranes; (2) with the azygos or hemiazygos systems, and (3) with the inferior vena cava. When this arrangement is considered it is seen that the circulation within the bodies of the lumbar vertebrae is interposed in a shunt-like manner in the horizontal connections among the three vertical venous systems mentioned above. In consequence, changes in the general venous or arterial pressures, due to increased intracranial pressure or to the necessity of the azygos, hemiazygos or posterior external plexus acting as collateral channels for the vena cava, would be transmitted to the venous channels within the bodies of the vertebrae (Fig. 3). It is suggested that prolonged alterations in systemic venous pressure should give roentgenological evidences of such change by producing variation from the normal in the calcification of the bone trabeculae of the vertebral bodies.

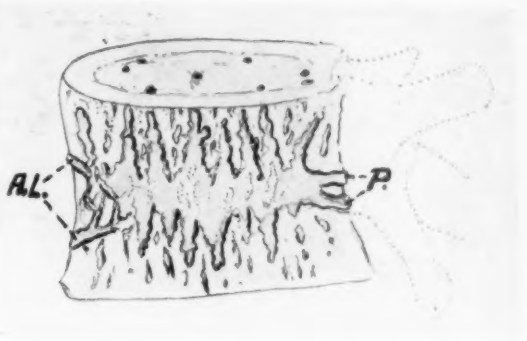

FIG. 7. Diagrammatic drawing of intervertebral venous sinusoids. *A. L.*—Anterolateral veins; *P.* —Posterior veins.

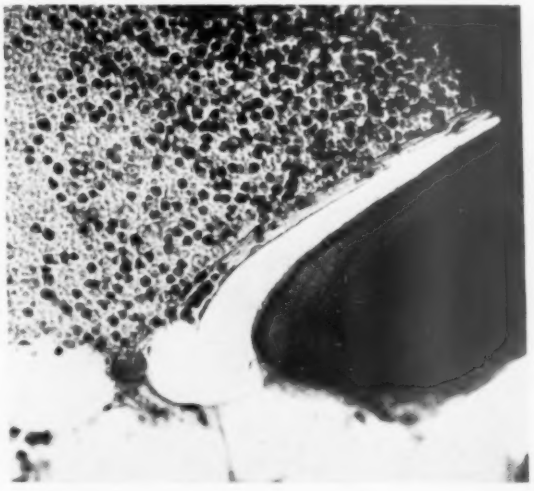

FIG. 8. Photomicrograph of a histological section (horizontal) of one of the more peripherally located venous sinusoids. The thin single cell limiting wall is shown separating the space from the bone trabecula; the sinusoid is similarly separated from the contacting fat cells. Various cellular elements of the contents of the sinusoid are recognizable. (Not retouched.) Same case as shown in Figure 6.

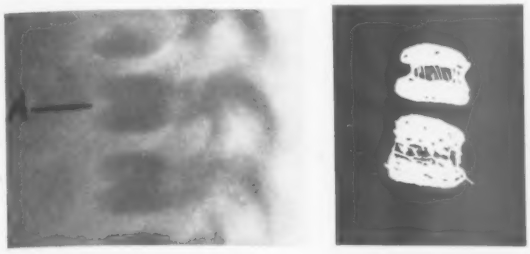

Fig. 9. Lateral roentgenogram and drawing of vertebra of an infant five days old. Note the zone of decreased density at *A*, where the blood vessels enter the body.

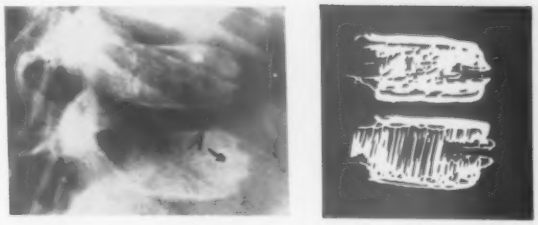

Fig. 10. Lateral roentgenogram and drawing of a vertebra of a boy six years of age, showing clearly the zone of entrance of the blood vessels at *A*. These are assumed to be the superimposed anterolateral vessels.

Venous Channels within the Vertebral Body. When serial horizontal sections are made of human vertebral bodies it is seen that the two posterior and the two anterolateral veins are in direct communication. These four veins meet in the central portion of the body and form a large reservoir. In general outline they form a letter "H", the upper side arms, formed by the two anterolateral veins, are bowed outward; the whole resembles somewhat the configuration of the gray matter of the spinal cord (Figs. 4 and 5).

The existence of these veins within the vertebral body is known and is the subject of occasional anatomical illustration. They are, however, always represented as being veins with definitely demarcating walls of normal venous composition. Such, however, is not the case.

Histological examination of a horizontal section of the vertebral body at the level of the emergence of the anterolateral or posterior veins shows that the walls of these vessels, beyond the vertebral periosteum, have the usual venous structure. This normal wall structure is immediately lost within the vertebral body and is replaced by a limiting membrane composed of a single layer of flattened endothelial cells (Fig. 6).

The common central origin of the four veins represents the main collecting basin of a vast intervertebral venous system.

Radiating peripherally from the central venous basin are many irregular columnar spaces. These spaces extend chiefly in the vertical plane and diminish in caliber and number as they approach the periphery (cortex). The majority of these vertical columnar spaces terminate in the vicinity

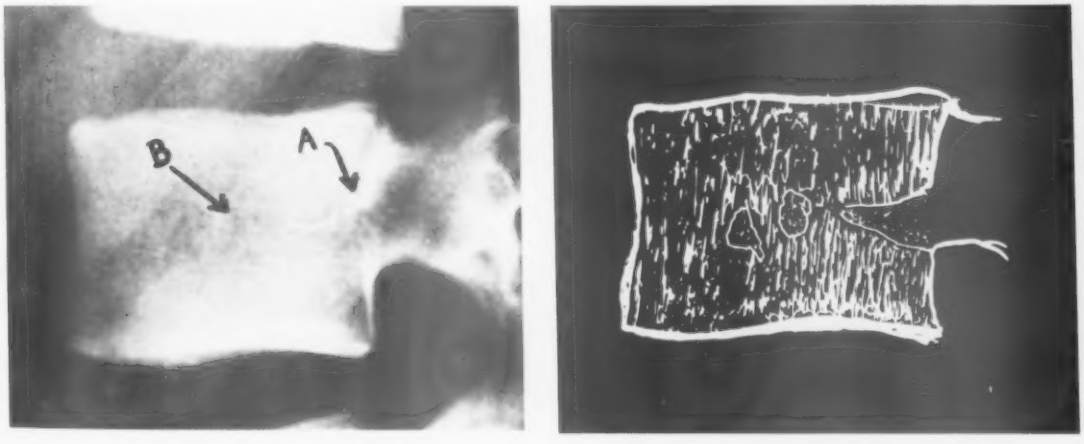

Fig. 11. Male aged fourteen. Lateral roentgenogram and drawing, showing blood vessel entrance at *A*, and sinusoids at *B*.

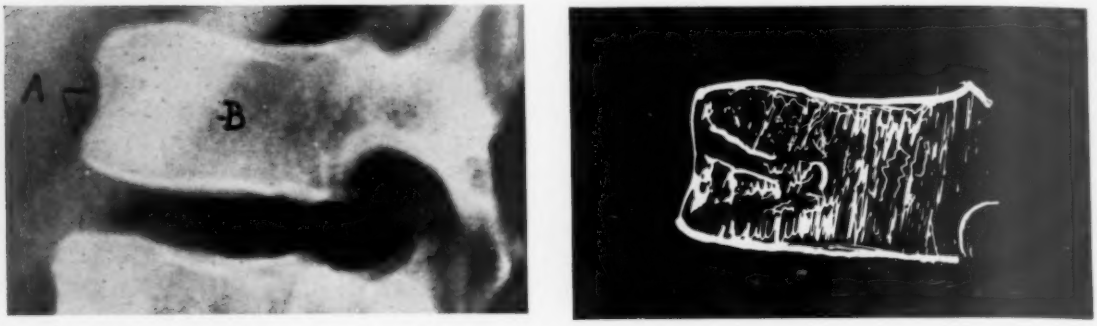

FIG. 12. Lateral roentgenogram and drawing of a vertebra of a normal boy, aged fifteen. Note the entrance of blood vessel at *A*, and possible sinusoids at *B*.

of the superior and inferior cortical zones. Some few pass through the end-plates, chiefly at their peripheries, and end at the surface of the intervertebral discs. Occasionally several invade the disc to a distance of approximately one-third of its thickness.

The columnar spaces are found chiefly in the cancellous portion of the vertebral body. Those located at the periphery usually extend vertically from disc to disc. Those located in the central area are broader and shorter, rarely penetrating to the end-plates. All tend to coalesce as they approach the central reservoir formed by the fusion of the four great veins previously described (Fig. 7).

When an attempt is made to estimate the volume of these irregular columnar spaces, their magnitude is appreciated. A horizontal cross section of the vertebral body at its center shows that the area of the spaces far exceeds that of the bone trabeculae. As the serial horizontal cross sections approach the inferior or superior end-plates the area of the spaces is found to be less than that of the bone elements. Vertical cross sections of the vertebral bodies show

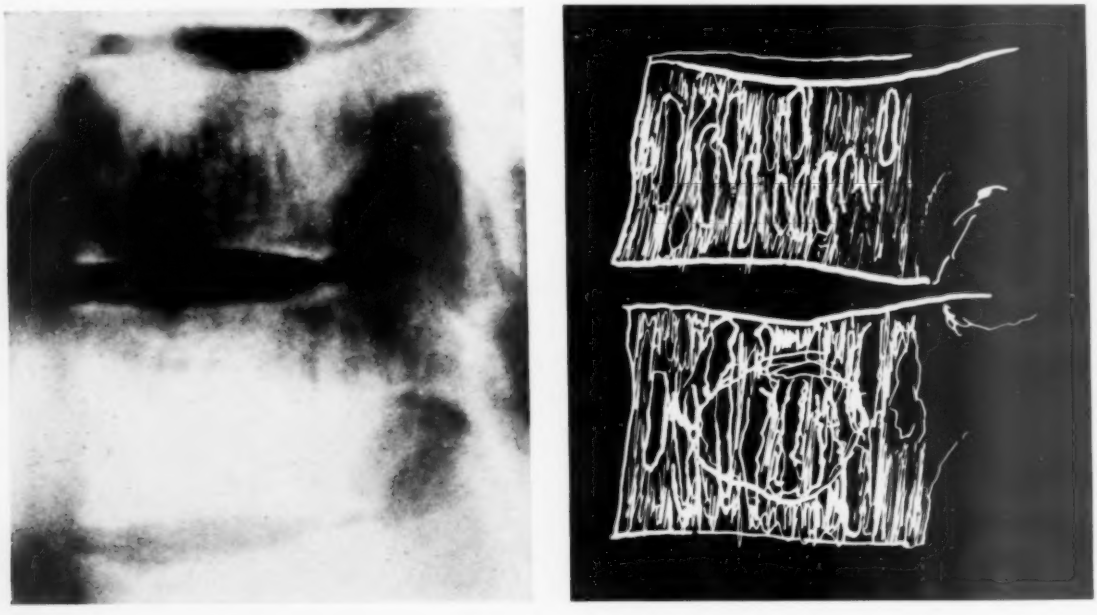

FIG. 13. Lateral roentgenogram and drawing of a case of Paget's disease. Note the appearance of the bony trabeculations that bound the sinusoidal channel.

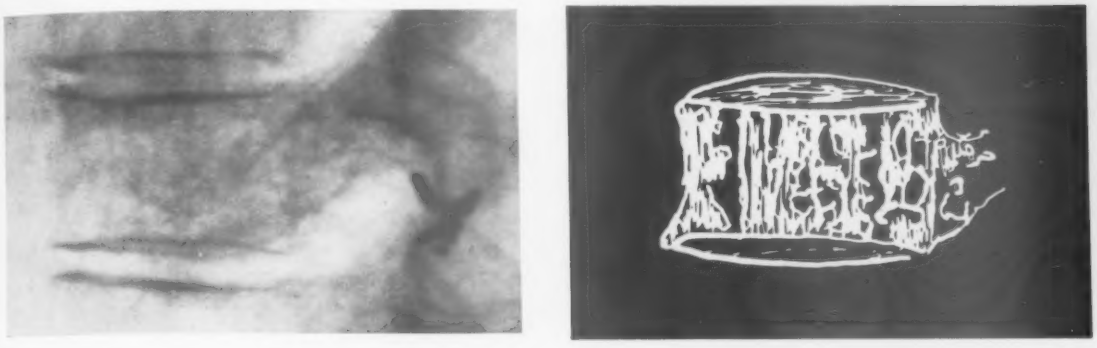

Fig. 14. Female, aged forty-six. Hemangioma of thoracic vertebra (confirmed). Note the appearance of the trabeculation of the vertebra. This illustrates the position of the vertical sinusoidal tracts.

much the same relation between spaces and trabeculae. It is roughly estimated that these ramifying columnar venous spaces occupy approximately 40 per cent of the entire vertebral body. (It would be advisable to substantiate these estimates by quantitative studies.)

Lining of the Venous Spaces. This continuous, irregular columnar tract is lined in its centrally lying portion by a single layer of flattened endothelial cells; in the more peripheral portion, the limiting wall is believed to be composed of histiocyte-like cells (littoral). Quite frequently the venous spaces are supported throughout a large portion of their circumferences by the bone trabeculae and their contents are separated from direct contact with the bone by the limiting wall of single cell thickness (Fig. 8).

Contents of the Venous Spaces. The venous spaces of the vertebral bodies in their central portion are filled almost solely with cir-

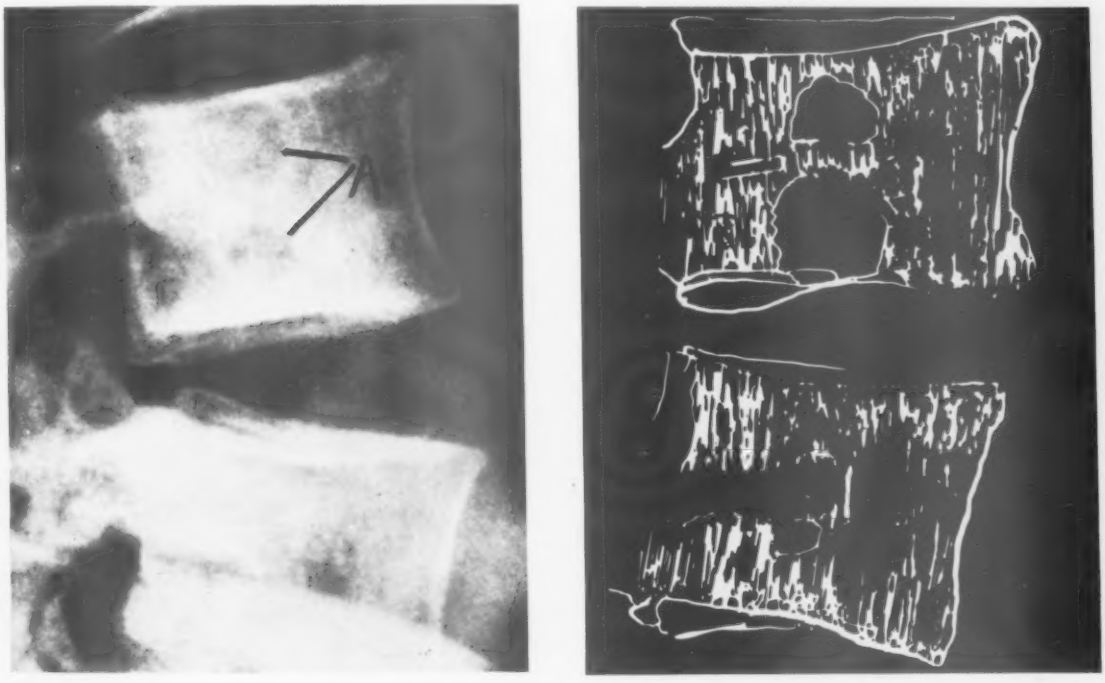

Fig. 15. Female, aged fifty-one. Lateral roentgenogram and drawing, demonstrating areas of metastases from carcinoma of the breast. Note that the area involved primarily is adjacent to the central sinusoidal reservoir.

culating blood elements. As the venous spaces lying distant from the central area are examined it is noted that their contents are composed of normal circulating blood elements and a varying portion of the cellular components of red bone marrow. The smaller and more peripherally placed venous spaces contain within their lumen a very large proportion of hematopoietic tissue, together with some reticulo-endothelial elements.* It is interesting to observe that the hematopoietic tissue does not remain localized to the more peripheral venous spaces but that these elements are occasionally found in fair number within the lumen of the central venous space. In several sections large numbers of marrow cells were found within the lumen of the extravertebral veins.

Incidence of Venous Spaces. Histological sections were made of human vertebral material removed at autopsy in 75 cases. This material was obtained from individuals of both sexes and of an age distribution from a six months fetus to a seventy-two year old adult. Microscopic examination of this material demonstrated the existence of the above-described venous spaces, together with their characteristic contents in all cases.

Nature of the Spaces. The demonstration of the existence within the bodies of the lumbar vertebrae of man of large, extensive and intercommunicating venous spaces, channels, or tracts raises the question as to their nature and function.

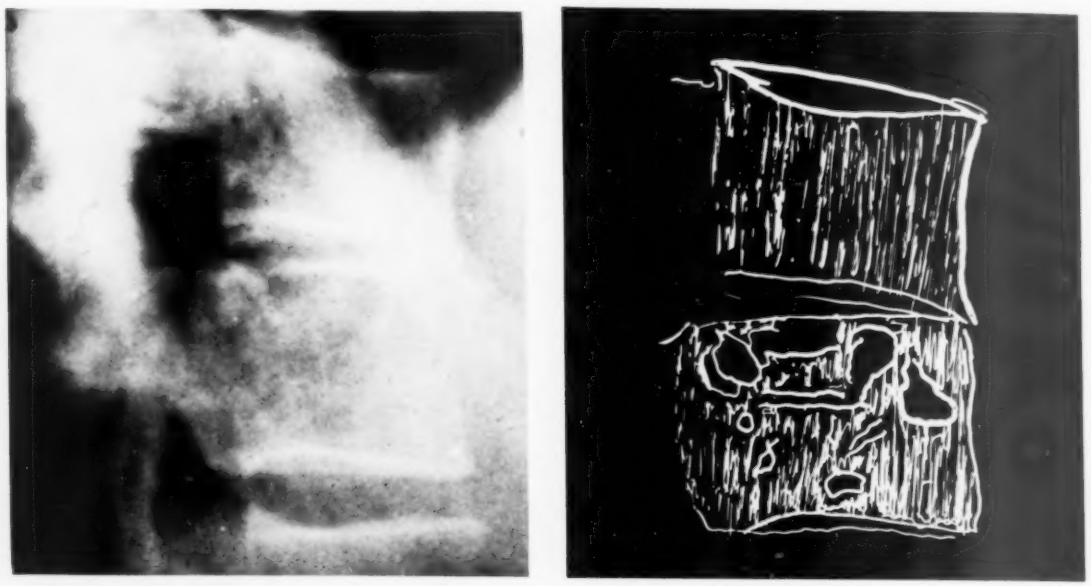

FIG. 16. Female, aged thirty-eight. Metastatic carcinoma involving the vertebra. Note that the intervertebral disc is disappearing, probably due to herniation into the body of the vertebra at the weakened point near the seat of the metastasis.

It is believed that these spaces are true venous sinusoids. Such an opinion is based upon the fact that these spaces ramify throughout the greater portion of the body of the lumbar vertebrae, that they intercommunicate, that they are lined in their central portions with a single layer of endothelial cells and in their distant bays by histiocyte-like cells, that they contain within their lumen hematopoietic tissue and normal circulating blood elements.

CLINICAL CONSIDERATIONS

The significance of the above studies are important for the following reasons:

* It is not the purpose of the present paper to deal with the cytological elements of the venous spaces described, nor to undertake a description of their more minute ramifications.

1. The vertebrae are concerned in the formation and destruction of the cellular elements of the blood. This area is thereby of importance in the roentgen treatment of blood dyscrasias.

2. The reticulo-endothelial elements present in the marrow of the sinusoids remove and destroy bacteria.

3. The sinusoids are a place of lodgment and removal of pyogenic bacteria and metastasis from the blood stream which is moving sluggishly.

4. The endothelial lining of the central space may share in the rôle of the development of primary malignancy other than bone in origin.

ROENTGEN CONSIDERATIONS

The usual roentgen examination of the spine includes two views: the anteroposterior and the lateral. It is our purpose to consider, briefly, some of the roentgen appearances observed in the lateral view.

The location of the anterior and posterior vessels supplying the bodies of the vertebrae are easily demonstrated on the roentgenograms up to the age of fourteen years (Figs. 9, 10, 11 and 12). It is impossible to demonstrate the sinusoidal system on the roentgenogram of the normal individual, but in conditions such as Paget's disease and hemangioma, it is possible to demonstrate an appearance that strongly suggests that of the sinusoidal channels (Figs. 13 and 14).

As the sinusoidal system becomes involved, any disease process spreads by extension and it is almost impossible to make a differential diagnosis without a complete history. Fractures, metastatic or primary malignancy and tuberculous caries of the vertebrae may at some stage of the disease simulate each other (Figs. 15, 16 and 17).

The anterior sinusoidal column extends up to the vicinity of the anterior edge of the intervertebral disc. This is frequently the site of a tuberculous process. This channel provides an easy means of access to the body of the vertebra. Furthermore, the anteroposterior channel affords an opportunity for direct extension of the infection posteriorly with extradural compression, or extension through the vascular system to neighboring vertebrae. It should be remembered that the vertebral marrow is an excellent medium (Fig. 17).

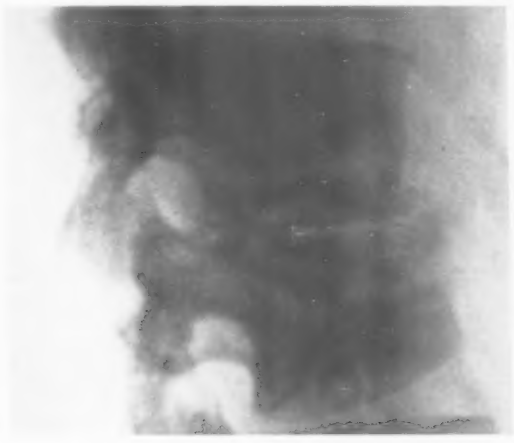

Fig. 17. Male, aged forty-two. Lateral roentgenogram and drawing of the lumbar vertebra diagnosed as tuberculous caries with cold abscess formation (confirmed). Note that the area of involvement is similar to that seen in metastatic carcinoma. Early, this patient had unilateral involvement of one vertebra. The extension to the second vertebra is presumably by vascular continuity. The disappearing disc was thought to be herniation of the disc into the vertebra. It would be extremely difficult to exclude metastatic malignancy if one did not know the history, physical findings and subsequent notes on this patient.

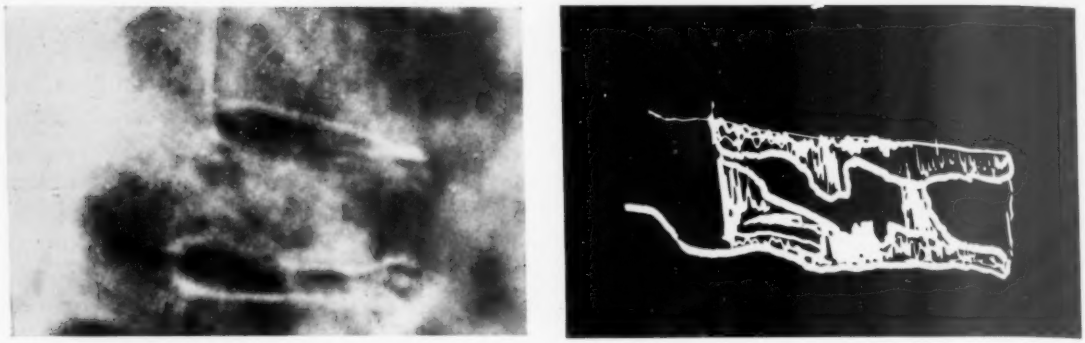

FIG. 18. Female, aged fifty-two. There is still further advanced metastases from carcinoma of the breast. In this case, the vertebral plates are intact, however, and there has been a general crushing of the body and no herniation of the intervertebral disc. Note that the metastasis has followed the line of the blood spaces. Furthermore in the anteroposterior film, there is, frequently, a beginning crush on one side and later both sides become involved.

After definite disease occurs, two factors seem to play an important rôle in the subsequent appearance of the vertebra: (1) the position of the pathological process and (2) the influence of the nucleus pulposus. For instance, if the cortical plate of the vertebra is weakened by a fracture, malignant or infectious process, the stress and strain of the nucleus pulposus will subsequently allow the intervertebral disc to herniate, partially or completely, into the body of the vertebra, resulting in a partial or complete loss of visible roentgen evidence of a disc (Fig. 16). If the upper and lower cortical plates of the vertebra remain intact, stress and strain will cause a uniform collapse of the vertebra with preservation of the intervertebral spaces as seen in the lateral view (Fig. 18). It therefore seems reasonable to believe that extension of the disease process is along the channels of the sinusoidal system, and that the appearance at any given time depends upon the location. If this be true, then the differential diagnosis will depend largely upon the clinical history.

SUMMARY

This paper comprises a consideration and description of the arterial and venous blood supply of the adult human lumbar vertebral body. A detailed study is made of one of the various intrinsic circulatory systems of the vertebral body, namely, the sinusoidal system. Particular and primary importance is given to the finding of a large sinusoidal plexus within the vertebral body. Its great extent and many ramifications are described. The fact that this sinusoidal tract is filled with hematopoietic tissue and constitutes a cellular bed through which arterial blood percolates and from which venous blood is collected is considered from the standpoint of its clinical importance.

The presence of the vertebral body sinusoids and their clinical importance are considered from a roentgenological standpoint. An attempt is made to explain the localization of various disease processes and their mode of extension within the vertebral body through a consideration of the intrinsic vertebral body circulation.*

* For discussion see page 831.

Vol. XXVII, No. 6

THE ROENTGEN SIGNS OF TUBERCULOSIS OF THE VERTEBRAL BODY*

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THE clinical aspects of tuberculosis of the spine have been frequently and fully described in the various surgical textbooks and clinical articles upon the subject. In spite of the well-recognized importance of the roentgen ray in the detection of early tuberculous lesions of the spine, little attempt has been made to similarly correlate the characteristic pathologic changes noted in the roentgenogram. Skillful interpretation of the roentgenogram is as essential as the special training required of the clinician to properly evaluate the signs which lead to an early diagnosis.

It is, of course, recognized from a scientific standpoint that the diagnosis of tuberculosis is not positive unless confirmed by biopsy, or the finding of the tubercle bacillus. The necessary procedures to make these tests are not always practical in spinal tuberculosis. It is frequently necessary to make a presumptive diagnosis which can be considered reasonably positive by the characteristic course of the disease. Sufficient corroboration of the characteristic pathologic changes noted in the roentgenograms of the early tuberculous spine has been afforded by the clinical course of the disease, by the late formation of an abscess superficial enough to permit aspiration for guinea pig injection, by tissue obtained in those cases complicated by a tuberculous pachymeningitis associated with cord symptoms requiring a laminectomy and by post-mortem studies.

To enable the roentgenologist to make an early diagnosis of tuberculosis of the spine, it is essential that he be well versed in the pathology of the lesion. The diagnosis should be made long before the characteristic picture of collapse of the body, loss of intervertebral space, and abscess formation are present. It is important to know the usual sites of the early lesion, and the characteristic progress of the lesion in these various sites. We have pointed out in a previous article[1] the significance of merely a slight narrowing of the intervertebral disc as an early sign in the so-called tuberculosis of the intervertebral articulations.

We have attempted to correlate the clinical knowledge and the gross pathologic picture of spinal tuberculosis with the evidence afforded by the roentgenogram. We feel that tuberculosis of the spine can be classified into various types, depending upon the anatomic location of the infection in the vertebrae. Progress of the lesion will develop characteristic changes that are peculiar to each type, and can be prognosticated from the appearance of an early lesion. We have studied 100 cases of tuberculosis of the spine which are the basis for this paper. The number of cases is small, but we feel the cases present an excellent basis for study, inasmuch as they represent a cross-section of tuberculosis of the spine occurring in individuals of all ages presenting themselves to a general hospital clinic.

AGE INCIDENCE AND DURATION OF SYMPTOMS

The average age was twenty-nine years. The youngest patient was two years of age and the oldest sixty-nine. Twelve patients were under ten years of age and 59 were thirty or under. It will be noted in Table 1 that the frequency, in this series, increases up to the age of thirty, after which it begins to decrease and after forty it decreases rapidly.

The duration of symptoms in this series is relatively higher than it would be if only

* Read at the Thirty-second Annual Meeting, American Roentgen Ray Society, Atlantic City, N. J., Sept. 22–25, 1931.

active cases were considered, as a number of these cases were of long standing and came in because of other complaints, but permitted us to study the old lesion.

TABLE I

AGE INCIDENCE AND DURATION OF SYMPTOMS

Age Period	Number and Percentage	Average Duration of Symptoms
0–10	12	10 months
11–20	14	38½ months
21–30	33	48½ months
31–40	21	52 months
41–50	10	6 years
51–60	4	12½ years
61–70	6	15 years
	100	6½ years

The average duration of symptoms was much lower during the first decade, and gradually but steadily rose with each succeeding decade of life. This, of course, is partly accounted for by old healed cases and by cases which had been under treatment for long periods. The average duration of symptoms in all cases was six and one-half years. The duration of symptoms was one year or less in 48 per cent of the cases, and from one to five years in 28 per cent. It would appear, therefore, that approximately one-half of these cases consulted us during the early stages of the disease.

MODE OF INFECTION

The general consensus of opinion has been that the mode of infection in spinal tuberculosis is by the hematogenous route in most cases. This is a metastatic process from some primary lesion which may be an active lesion at the time or an old partially healed one. It would follow then that the exact localization of the lesion in the vertebra would depend on the blood supply. In a previous communication[1] we described the blood supply as worked out by Lexer by means of injection methods. This mode of infection explains fairly well the lesions seen in the vertebrae themselves, but it does not explain so well the fact that in a number of cases the roentgen picture shows definite involvement of the disc without any evidence of involvement of the vertebra.

This has led to a study of the disc and its blood supply to ascertain if there was a possibility of infection beginning in the disc in certain cases. A detailed study of the disc has recently been reported by Smith.[4] He reports that in the nucleus pulposus he discovered a central cavity and in many cases there were villi projecting into it from the wall. The villi were cellular and were of irregular size and shape. He also found evidence of nutritive channels in the disc. It has been thought previously that nourishment is provided by diffusion currents from the spongiosa of the vertebrae. These nutritive channels come from the marrow of the vertebral bodies and pierce the cartilaginous plates of the disc, passing thence between the fibers of the annulus fibrosus and reach the nucleus pulposus.

The fact that blood vessels exist in the disc and pass to the nucleus pulposus, which contains a cavity with cellular villi present in it, makes it very likely that infection could occur in the disc either as the first focus or coincident with the infection in the vertebra. This would explain the roentgen picture in certain cases. It is also possible that some of the cases of the intervertebral type might originate in the disc and spread to the vertebra.

In spite of the more or less general acceptance of the blood-borne type of infection, there are some who believe in the lymphatic system as the route by which infection takes place. Fraser[2] has recently drawn attention to this theory. He calls attention to the fact that the lymphatic nodes and vessels are the primary vehicles and sites of infection and that a blood infection is a secondary phase to a primary involvement of the main lymphatic trunks. He calls attention to the fact that the thoracic lymphatic duct is in intimate contact with the anterior ligament covering the anterior surface of the vertebral column in the portion of the spine that has the maximum incidence of infection, and that the great bulk of abdominal lymphatics

are situated over the lower dorsal and upper lumbar area.

Fraser further states that cancellous tissue containing red marrow is highly resistant to tuberculous infection, but that if there is degeneration of the marrow, the cancellous tissue is peculiarly likely to become infected. He believes that this degeneration of the marrow is produced by a tuberculous infection of the lymph nodes and lymphatics overlying the vertebra.

In view of the fact that infection by the lymphogenous route is not proved, and that our suggestion as to infection originating in the disc in certain cases is only a theory which also is not proved, we will describe the lesions according to the commonly accepted hematogenous mode of infection.

CLASSIFICATION OF TYPES

Tuberculosis of the spine can be divided into various types, depending upon the anatomic location of the infection in the vertebra. In the study of this series of 100 cases of tuberculosis of the spine, we have attempted to determine the anatomic type of infection in each case, and the following description is based on this study.

Fig. 1. Central type of involvement of the first and second lumbar vertebrae. Primary involvement of the first and infection of the second, probably by continuity. (Retouched.)

Fig. 2. Central type of involvement. At the first examination, there was collapse of the body of the fifth dorsal vertebra only. At the second examination, there was much débris in the region of the fifth dorsal vertebra and contact infection of the fourth dorsal vertebra. There was a secondary infection of the eighth and ninth dorsal vertebrae with collapse of the body of the eighth. Calcification in an abscess was seen anterior to the dorsolumbar area. (Retouched.)

We are able to differentiate roentgenologically three main types of involvement of the body of the vertebra: (1) central type; (2) intervertebral articular type, and (3) anterior type. There is also a fourth type of infection which involves the vertebral appendages but we have had no cases of this type.

Central Type. The infection in this type comes through a branch of the posterior spinal artery and involves first the central portion of the body of the vertebra. The area of destruction gradually enlarges until most of the vertebral body is involved and then, because of the transmitted pressure upon it, the body collapses with the appearance of the characteristic kyphosis. As the area of destruction spreads through the body of the vertebra, the epiphyseal portion becomes involved, with consequent destruction of the intervertebral disc. The tuberculous process then spreads to the

adjacent vertebrae, either by involving the contiguous portion of the articular surface of the body, or it spreads beneath the anterior longitudinal ligament and involves the anterior portion of the body and later the central portion.

This is the most frequent type found in children and all cases in this series under twelve years of age were of the central type, and all but 4 under twenty were of the central type. In all cases but one of the central type under twenty, there was collapse of the body of the vertebra. The central type of lesion did not show a predilection for any region but was well distributed throughout the spine.

In cases with the central type of involvement, there may be few symptoms in the early stages of the disease. It was usually after collapse of the vertebrae had taken place that these cases were seen, and this absence of early symptoms may be the reason why 86 per cent of the central type, in this series, showed collapse of the affected vertebrae.

Intervertebral Articular Type. The articular margins of the vertebra are supplied by the epiphyseal arteries, which are branches of the posterior spinal artery, and it is through these arteries that the infection takes place.

In this type, the infection begins along the articular margins of the body of the vertebra and consequently there is early involvement and destruction of the intervertebral disc. Narrowing of the disc is one of the earliest roentgen signs in this type. There is also early involvement of the adjoining vertebral articular surface. Abscess is also commonly found early in the course of the disease. Symptoms usually occur while the disease is still in its early stages and therefore we have found many more early cases of this type than of the central type.

As the disease progresses, there is gradual excavation from the articular surface toward the central portion of the body of the vertebra. The destruction may also extend to the anterior portion of the vertebra and when this point is reached, there is generally collapse of the body of the vertebra, as was noted in the central type. Collapse of the vertebra in the intervertebral type is unusual. In this series we found only 10 per cent of the cases with this type of infection which showed collapse.

In cases which are diagnosed and properly treated early in the course of the disease, there is healing with very little deformity in the shape of the bodies of the vertebrae and in favorable cases they may even heal without the bodies becoming fused. In cases further advanced they become fused in a more or less parallel manner with very little external deformity.

Anterior Type. The anterior portion of the body of the vertebra is supplied by branches of the intercostal arteries entering through the anterior longitudinal ligament. The infection spreads along the surface beneath the anterior longitudinal ligament and tends to remain superficial, but may involve a number of vertebrae. It may invade the body of the vertebra, however, and it then resembles the central type with destruction and collapse of the vertebral body.

This type is also apparently produced by contact infection from tuberculous abscesses originating in neighboring vertebrae. This is shown by the fact that while there were 8 cases of anterior involvement in this series, only 2 were of the pure anterior type. The other 6 cases showed anterior involvement but were seen in combination with the other types. In these cases it begins either as an anterior type and spreads beneath the anterior longitudinal ligament to an adjacent vertebra and involves the intervertebral portion of the body, or the infection begins as one of the other two types and the abscess spreads beneath the anterior longitudinal ligament and involves the anterior portion of the neighboring vertebrae, as it did in several of these cases. Collapse of the vertebral body is a late occurrence with this type of infection.

We had no cases in this series illustrating tuberculosis of the vertebral appendages.

It will be noted in Table II that more than one hundred lesions are listed under different types, but this is accounted for by the fact that some of the cases were of the mixed type, presenting several types of lesions in the same case, especially those of multiple or skipped infection.

FREQUENCY ACCORDING TO LOCATION AND TYPE OF LESION

There was involvement of the cervical spine in 2 cases in this series. This is a somewhat smaller percentage than has been reported in other series, where it ran from 7 to 26 per cent. One of these cases showed a central type of involvement and the other was of the intervertebral type.

The dorsal spine is a frequent site for tuberculosis, especially the lower half of this area. Forty-four cases in this series had involvement of the dorsal spine; 36 of these cases showed the central type of involvement and 8 were of the intervertebral type. Other series report from 40 to 60 per cent of the cases in the dorsal spine.

The dorsolumbar articulation has been considered separately because it is neither dorsal nor lumbar entirely but involves each. There were 18 such cases in this series; 7 were central in type, 7 were intervertebral, and 4 were of the anterior type. In Steindler's series[5] 15 per cent of the cases involved this area.

In the lumbar area there were 45 cases in our series, which is somewhat higher than in other reported series which give from 19 to 30 per cent. In this area, 17 of the cases were of the central type, 24 were of the intervertebral type, and 4 were of the anterior type.

TABLE II

INCIDENCE AS TO TYPE AND LOCATION OF LESIONS

Area	Central	Intervertebral	Anterior
Cervical	1	1	0
Dorsal	36	8	0
Dorsolumbar	7	7	4
Lumbar	17	24	4
Total	61	40	8

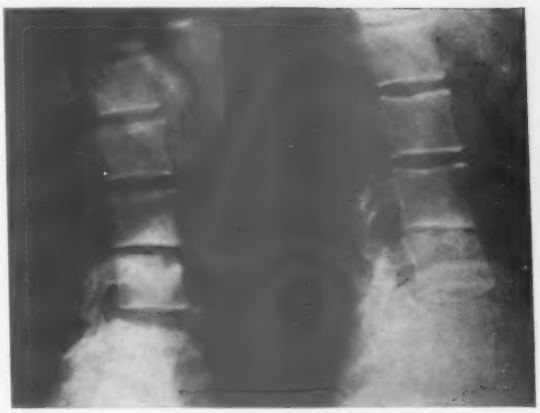

FIG. 3. Intervertebral type of involvement early and after becoming quiescent. This shows relatively little deformity before or after.

In analyzing these figures, it is seen that the central type is much more common in the dorsal area than is the intervertebral type, but in the dorsolumbar area they are equal in number, and in the lumbar area the intervertebral is somewhat more numerous than the central type.

INTEGRITY OF THE BODY OF THE VERTEBRA

As the bodies of the affected vertebrae become infiltrated and soften, the superincumbent weight of the body above this point produces collapse of the affected vertebrae in their anterior portions and produces the well-known kyphotic deformity.

In studying the cases in this series, we found that there was collapse of the vertebrae in 54 cases and preservation of the vertebral body form in 46. Twenty-four per cent of the cases had had symptoms for more than five years and among these cases the percentage of deformity is very high. It is felt, therefore, that the percentage of collapse among the more recent cases is much lower than that pertaining to the entire series.

In the 46 cases without collapse of the bodies of the vertebrae, 36 were found to be of the intervertebral articular type and 2 were of the anterior type; the remaining 8 were central in origin. This demonstrates the relative infrequency of deformity re-

sulting from the intervertebral type of infection, and the relative frequency of deformity associated with the central type. The anterior type, as a rule, also shows preservation of the vertebral body form.

TABLE III

INTEGRITY OF THE BODY OF THE VERTEBRAE

	Collapse of Vertebra	Non-collapse
Central type	50	8
Intervertebral type	4	36
Anterior type	0	2
Total	54	46

In studying the 54 cases in which collapse of the body of the vertebrae occurred, 50 were found to be of the central type and 4 had their origin in the intervertebral articulation. These latter figures might have to be revised somewhat if the series represented only recent active cases, as many of our old cases presented such marked destruction and deformity that we have had to classify them as central in origin owing to the fact that the whole body was destroyed.

FIG. 4. Showing anterior involvement of the first lumbar vertebra secondary to infection of the eleventh and twelfth dorsal vertebrae. (Retouched.)

DISC

Tuberculosis of the spine has always been thought to have its earliest changes in the body of the vertebra with secondary involvement and disappearance of the intervertebral disc. With the advent of the roentgen examination it has been found that in most cases the earliest demonstrable roentgen change is narrowing or obliteration of the disc. In some cases, abscess formation is the first sign but in nearly all of these cases there was narrowing of the disc at that time or shortly thereafter. We have felt that the technical difficulty in showing the minute bone changes in a thick part of the body, such as the trunk, as compared with demonstrating narrowing of the disc was sufficient to account for this discrepancy. This early narrowing of the disc could easily be accounted for, however, by the infection beginning in the disc as suggested above.

In going over the films of these cases we found apparently complete disappearance of the disc in 83 cases, and definite narrowing of the disc in 17 cases. In no case did we find a normal disc. We have seen some instances in young children where kyphosis was the first sign and where the vertebra was entirely destroyed without a correspondingly severe degree of involvement of the disc. This must mean that the disease of the vertebra was devoid of symptoms until there was collapse of the body and some involvement of the disc.

ABSCESSES

Abscess is the most common complication of spinal tuberculosis, and was found in 84 cases. These were not all discovered by the roentgen examination, as some were present at the first clinical examination, and others developed during the period of observation; the largest number, however, were demonstrated roentgenologically.

In analyzing the frequency according to location of their origin, we found the following data: In the cervical spine both cases had abscess formation. In the dorsal spine, out of 44 cases there were 39 with abscess formation, or 88 per cent. In the lumbar spine, there were 31 cases of abscess formation in 45 cases, or 69 per cent. In the dorsolumbar spine, we found 12 abscesses among 18 cases, or 67 per cent.

Abscess formation may be the very first roentgen evidence and may be present before any bone change is noted. This is true especially in the intervertebral type, as we have previously pointed out. We have seen a number of cases also in which the presence of abscess led to a careful search of the spine and the disclosure of an early spinal lesion. The presence of paravertebral abscess is almost pathognomonic of spinal tuberculosis and its presence demands careful examination and continued observation of the spine over a long period of time.

Calcification of abscesses is a frequent accompaniment of healing and in one of our cases previously reported[1] there is well-marked calcification two years after the beginning of treatment of an early case.

TABLE IV

FREQUENCY OF ABSCESS ACCORDING TO POINT OF ORIGIN

Location	Number of Cases	Number of Abscesses	Percentage
Cervical	2	2	100
Dorsal	44	39	88
Dorsolumbar	18	12	67
Lumbar	45	31	69

MULTIPLE OR SKIPPED INFECTION

We mean by this two areas of tuberculosis with apparently normal vertebrae between these areas. This is said to be rather rare and Peabody[3] reports its presence in 4 per cent of a series of cases. Among the recent cases, in his series, which had complete data, he found 8 per cent as the incidence and he believes that the real incidence may be even higher than the latter figure. He also found practically all of the secondary lesions lower in the spine than the primary lesions and concluded that they were probably produced by contact with the gravitating pus.

We found 10 cases of multiple infection in this series, or 10 per cent. In 7 of these cases, the secondary lesion was above the primary, and in 3 cases it was below the primary. In 7 cases the lesions were close enough to each other to suggest that infection may have resulted from direct extension by gravitating pus. In 3 of these cases, however, the lesions were widely enough separated to suggest an entirely new lesion. It is possible, therefore, that this multiple type of infection may have its origin either by contact with pus from the original lesion or by a new hematogenous infection.

ASSOCIATED TUBERCULOUS LESIONS

The usual conception of Pott's disease is that it is a part of a generalized tuberculosis which may or may not be active at the time. It has also been known that the pulmonary lesion is the most commonly manifested concomitant lesion and Steindler found that 17 per cent of his spinal cases showed a concomitant pulmonary lesion.

In our series we found 24 patients who had a pulmonary lesion associated with the spinal lesion. One of these developed under our observation while we were treating the spine and later became quiescent. The next most common area to be affected was the genitourinary tract in which it was present in 8 cases. Tuberculous abscesses not associated with the spine were present in 7 cases. Six cases had evidence of tuberculous joints outside of the spine. Tuberculous glands were found in 3 patients; 3 died of tuberculous meningitis and 2 had tuberculous osteomyelitis of other bones.

SUMMARY

1. Attention is called to the fact that the roentgenologist must know the pathological findings in tuberculosis of the spine and must be able to correlate these with the corresponding roentgen signs. A series of 100 cases are included in this study.

2. The age incidence in this series was studied; the average was found to be twenty-nine years. The average duration of symptoms at our first examination was six and one-half years.

3. The mode of infection is discussed and the hematogenous route is favored, but the lymphogenous route may also play a part. A suggestion is made that in some cases the primary infection may be in the disc.

4. Roentgenologically, we distinguish the following types of tuberculous involvement of the body of the vertebra: (1) central type; (2) intervertebral articular type, and (3) anterior type.

5. We have tabulated the frequency of the various types of infection according to the location in the spine and find that the central type of lesion is more common in the dorsal area and that the intervertebral type is more common in the lumbar area.

6. The central type causes collapse of the body of the vertebra in a high percentage of cases, while in the intervertebral type, the vertebral body form is preserved until late in the disease.

7. Narrowing of the disc is the earliest and most constant roentgen sign in tuberculosis of the spine.

8. Abscess is the most common complication and was found in 84 per cent of the cases in this series at some stage of the disease.

9. Skipped infection, or two areas of infection with normal vertebrae between, was found in 10 per cent of the cases.

10. Concomitant tuberculosis in other parts of the body was found in 53 instances. The pulmonary lesion was the most common concomitant lesion and was present in 24 cases.

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DISCUSSION OF PAPERS BY DRS. EVANS, WAGONER AND PENDERGRASS, AND DOUB AND BADGLEY

DR. A. BRUCE GILL, Philadelphia. Such a wealth of material has been reported to us in these three papers that I hardly know what portions of them to discuss. I was particularly impressed with the great value of Dr. Evans' paper.

In medicolegal cases there has been at times marked divergence of expert opinion, both as to diagnosis and as to etiology of certain conditions of the spine. Dr. Evans' paper should aid in clarifying the situation because he has gathered together all conditions and has made it much easier for the surgeon and the roentgenologist to make a correct diagnosis by comparison. Vertebral anomalies are quite common, and many times are found to be present in individuals who have never suffered from any symptoms referable to these anomalies. On the other hand, some of them, such as sacralization of the fifth lumbar vertebra or elongation of its transverse processes which may even articulate with the pelvic bones, may be productive of pain and disability, particularly after an injury to the back. Therefore, it may at times be difficult to state whether the symptomatology is due entirely to injury or to the anomalous condition of the spine.

The various types of wedge-shaped vertebrae which Dr. Evans has shown are in some cases congenital or developmental conditions, but might easily be diagnosed as compression fractures and be ascribed to an injury.

Therefore, if we will consult Dr. Evans' comprehensive paper before testifying in court as to any vertebral condition appearing in the films we may avoid the expression of an erron-

eous opinion. I believe that Dr. Evans' paper is one of the most valuable I have ever had the pleasure of hearing.

Dr. Wagoner's work is a very valuable and fundamental one. For years Lexer's has been accepted as the chief outstanding work on the circulation of the blood in the bones. Dr. Wagoner now carries this work out in greater detail in the vertebrae and demonstrates the histology and structure of the bone as well as the circulation. The presence of the large stagnant lakes of blood within the body of the vertebra helps to explain the fact that tuberculosis of the spine is the most common type of bone tuberculosis. One might expect that acute osteomyelitis of the spine would occur frequently for the same reason, whereas it is quite rare. It seems probable that the tubercle develops favorably in cancellous bone containing red bone marrow, whereas the pyogenic microorganisms are more readily destroyed by phagocytic action in this same location.

The third paper in this symposium is also an interesting and valuable one. Orthopedic surgeons have noted these various types of vertebral tuberculosis. We have for years believed that the earliest sign of disease to be noted in the roentgenograms is the absorption of the intervertebral disc. Dr. Doub and Dr. Badgley state that intervertebral tuberculosis is not nearly so common as is the central type or the anterior type. Why is it that in practically all types we find narrowing of the disc? My opinion is that the intervertebral disc atrophies because its blood supply becomes cut off by the underlying disease. Tubercle is primarily a tuberculous endarteritis. Blood vessels are occluded early in the process. Dr. Wagoner has demonstrated the vascular communications of the vertebral body and the intervertebral disc. Therefore we may readily understand the early atrophy of the disc. On the other hand, absorption of bone is a slow process in tuberculosis and is not apparent by the x-ray in the early stages of the disease. I think these facts may account for the apparent discrepancy that the disease originates in the body and that the first roentgen evidence is in the intervertebral disc.

There is another interesting feature that central tuberculosis may be present for a long time without producing symptoms. That is true of tuberculosis elsewhere; when it involves bone alone, it has few symptoms. Why? Because there is no tension within the bone. It is a slow chronic process. There is no great outpouring of serum or cells. Its progress is slow and it is only when it approaches, for example, at the end of a long bone the periosteum, which is sensitive, that we have some effusion underneath the periosteum which lifts it up and that then there are such symptoms as pain, tenderness and limitation of motion. This symptomatology, of course, in the spine would be absent as long as the disease is confined to the central portion of the body. Whereas in those other cases involving the anterior or superior portion, where it comes early to the surface, we have early symptomatology and more early recognition.

I feel very much honored in having been asked to be present at this meeting and I have been tremendously interested in these papers.

Dr. O. V. Batson, Philadelphia. I appreciate very much the privilege of being here as guest and having the opportunity of discussing these papers. I wish to comment especially on the bodies of the cervical vertebrae. The first two cervical vertebrae are almost normally anomalous. Their peculiarities arise from the changes which have occurred in the course of their development. The first cervical vertebra is the only vertebra which normally has an anterior arch. The anterior arches in the remaining cervical vertebrae have disappeared, except for their occasional persistence in the region of the intervertebral disc. This persistence of the arch seems to account for the numerous fusions which we find between the first, second and third cervical vertebrae.

When we think of the bodies of the cervical vertebrae, we should also include the pars basilaris of the occipital bone, because it is really a vertebral body and participates in the anomalous conditions which we find in the upper cervical region.

A further peculiarity of bodies of the cervical vertebrae is found in the fact that at least one-third of their substance is derived from the ossification centers of the lateral masses of the vertebrae. The lateral mass does not participate to such a large extent in the formation of the vertebral bodies in other regions.

I presume that Dr. Evans did not wish to discuss the general bone diseases, which also involve the bodies of the vertebrae. I am thinking particularly of osteopoikilosis or spotted bone, which shows both as a condensation and thinning in the bodies of the vertebrae, of cystic

disease of the vertebrae, and of actinomycosis.

Dr. Wagoner has been interested in the presence of bone-forming and bone-destroying tissue, which he has found in such large quantities in the bodies of the vertebrae. I feel that we should remember that this venous sinusoidal system, which connects the interior of the vertebral canal with the exterior, corresponds very closely to the system of diploic veins in the skull. The systems are not quite identical, because of the differences between the cranial and spinal dura mater. If we accept Schüller's ideas, we should expect an increase in intracranial and intraspinal pressure to cause a transmission of the arterial pulse to these sinusoids, with a resulting change in bone density. Because of the greater extent of the sinusoids in the vertebrae, the change would probably be less marked than in the skull.

May I offer one point about the bone marrow in tuberculosis. Anatomical preparators seek the skeletons of individuals dying of generalized tuberculosis because the fat of the bone marrow, especially in the vertebrae, has been so reduced that it is not necessary to extract the grease from the bones in preparation. This is gross evidence of the marked change that has taken place in the body of the vertebra in this condition.

DR. S. W. DONALDSON, Ann Arbor, Mich. Statistics reveal the fact that about 20 per cent of all spines show some deviation from the normal and normal formula. This deviation is most common in the lower spine, that is, the coccyx and sacrum, and then decreases in incidence from here upward. Sacralization of the last lumbar or lumbarization of the first sacral segment, with or without a failure of closure of the posterior arch, is quite common and has been given considerable study. Then less common are the changes in the dorsal region, and the cervical is seldom affected.

One of the changes at the junction of the lower dorsal and lumbar region is when the lumbar takes on dorsal characteristics and shows either a unilateral lumbar rib, or a long narrow lateral process with a failure of fusion of the tip. This is sometimes interpreted as a fracture of the lateral process and is of medicolegal importance when one must determine whether or not there has been a fracture.

The intercalations and excalcations exist in the dorsal region and are also of legal importance as they are congenital abnormalities. As the individual grows, there is sufficient adjustment to compensate for the deformity and finding it by x-ray is usually incidental, often after an injury, or as in two of our cases who had had chiropractic manipulations, had gone to a physician afterwards, and then been sent for a roentgen examination fearing an injury had been done. As pointed out by Dr. Gill, these congenital deformities are quite common and discovery of the existing condition after an injury in many cases brings them into the medicolegal field.

Compensation is getting to be quite the thing, and claims of traumatic arthritis based on roentgen findings are not unusual. Films are exhibited showing lipping of the borders of the bodies of the vertebrae which has been interpreted as indicative of arthritic changes. Nevertheless this is only a senile change, and not of great enough clinical importance to be considered occupational and compensable.

In any new work, such as herniation of the nucleus pulposus, one must be careful in making such a diagnosis The men doing legal work will in all probability be called as referee in cases where overenthusiasm has led to interpretation of a herniation when there is only a very slight change in the disc or border of the vertebra.

The abuse of the roentgen film in court is common. In spinal cases especially, where there is a deformity, and experts have been called to testify whether this deformity existed before the injury or is the result of the injury, the attorney may have the films demonstrated to the jury and win their sympathy. He usually dwells extensively on the severity of the injury and the disability which this person suffers from a "broken back." If the spine is not perfectly straight, it is difficult for the expert to offer any convincing argument that this is a congenital anomaly or the result of a disease process which existed prior to the injury.

DR. RALPH S. BROMER, Philadelphia. These papers have been so comprehensive that I think there is little to add. However, since Dr. Evans mentioned some difference of opinion in regard to the diagnosis of the rachitic spine case, I might say that I think it possible that it is a case of the disordered epiphyseal development recently described by Ruggles. If so, the extremities should show much distorted epiphyseal centers, apparently stunted in growth. Wedge-shaped vertebral bodies, on the other

hand, are also found in rickets. The examination of the extremities should be of assistance in the differential diagnosis.

The second slide which Dr. Evans showed, of the vertebral bodies with dense bands at the superior and inferior borders, might be due to rickets. But other conditions can also cause such a piling up of calcium at the vertebral borders and, here again, examination of the extremities in order to find evidence of coincident pathologic changes might determine the diagnosis.

Dr. Wagoner (closing). In answer to Dr. Gill's question relative to osteomyelitis of the vertebral bodies, I think its infrequency is due to the preponderance of the reticulo-endothelial elements in the sinusoidal spaces of the vertebral bodies, which material or cells have a high phagocytic power.

The prevalence of tuberculosis, on the other hand, I believe due to the presence of the large amount of red marrow. I doubt very much whether tuberculosis of bone occurs in any other site than one in which red marrow is present; even in the shafts of the long bones when tuberculosis occurs there, I believe it must be within islands of arrested red marrow.

Whether or not lymphatics exist within the bone, I am unable to say, although I strongly believe they do.

Dr. Doub (closing). I wish to say just a word in regard to Dr. Gill's question about early destruction of the intervertebral disc. I agree with him that disintegration of the disc and destruction is, in all probability, due to destruction of the blood circulation of the disc. In the central type, if we get cases early enough I believe it would be possible to see tuberculosis in the body of the vertebra before involvement of the disc. I think that is shown in one slide that I showed here. In this case there was apparently involvement of the fifth dorsal vertebra only, in the first films. Two months later there was definite narrowing of the disc and destruction of the body of the eighth dorsal vertebra. In a restudy of the original films, which I have at the hospital, there is a suggestion of involvement of the center of the body in the first film which we passed up. There was no narrowing of the disc, however, even on careful measurement, but in the last one, two months later, there is definite involvement of both. In the intervertebral type, I believe the early narrowing of the disc is ac counted for by the fact that the infection begins along the articular surface of the body where the disc is attached, and therefore the circulation of the disc is early destroyed and we get disintegration and destruction.

THE COLON AS STUDIED BY THE DOUBLE CONTRAST ENEMA

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THE usefulness of examining the colon with the usual barium enema has long been established and its value is well recognized in the study of colonic gross morphology, anomalies of defective development, adhesions, inflammatory, granulomatous and neoplastic processes. There are limitations, however, to this examination and because of their technical aspects these are sometimes appreciated only by the roentgenologist. The difficulties are primarily due to inability to completely fill the colon with the opaque mixture or to the impossibility of carrying out proper palpation, especially of the splenic flexure, the cecum and the sigmoid. Satisfactory visualization and separation of redundant portions, particularly in the presence of adhesions, is frequently unattainable and it is almost always impossible to demonstrate early mucosal pathological processes like polyps, adenomas, ulcers and carcinomas by the use of a single contrast enema. The double contrast enema is a distinct aid in all these difficulties, sometimes being the only method of obtaining a completely satisfactory examination; at other times it may be only a supplementary method. On the other hand, we have not found it indispensable as a routine aid since in the majority of cases the single contrast enema yields all the information obtainable. Unfortunately, one cannot always foretell if all the obtainable information has been

FIG. 1*a*. Single contrast enema examination of isolated colon from cadaver.

FIG. 1*b*. Double contrast enema examination of the same colon using vertically directed roentgen rays with the colon in the horizontal position. Note the sharp, etched-like colonic margins, the uniform coating of the mucosa, the residues of opaque contents in the dependent haustra and the sharp, complete delineation of all the haustra.

properly demonstrated until the older single contrast method is followed with the double contrast enema. It is for this reason that we think it advisable to use this newer method routinely.

Fischer[1] seems to have been the first to use the double contrast enema method of studying the colon and he very carefully reviews all previous efforts made in the study of the colon with air insufflation as practised before his report. Air has long been used as a contrast medium in the roentgen visualization of pathological processes in hollow viscera, canals and cavities. This is attested by the elaborate literature now accumulated on ventriculography, encephalography, pneumothorax, pneumocystography, etc., but air as a medium for contrast visualization of the colon has never been popularized because, when used by itself, the contrast produced against the neighboring, partially air-filled intestinal segments is not great enough and the outline of the colon is therefore often indis-

FIG. 2*a*

FIG. 2*b*

FIG. 2*a*. Elongated, redundant and reduplicated sigmoid and pelvic colon whose walls are not discernible throughout because of overlapping, even though this roentgenogram was made with rotation of the patient to best demonstrate them. Note incomplete filling of the cecum and filling defects in the lower descending colon, the differentiation of which between polyps and fecal material is not definitely possible.

FIG. 2*b*. Double contrast roentgenogram of the same colon made with horizontally directed dorsoventral rays with the patient in the erect position. The outline of the entire colon is now clearly discernible throughout; the sigmoid overlaps the transverse segment and is held up and fixed in this position. The cecum is now completely filled and is regular in outline. No filling defects are visible in it. Several polyps are visible in the lower descending colon (visible always in the same location with the patient in other positions) substantiating the nature of these defects.

This patient was studied in the gastro-enterological department of the Graduate Hospital by Dr. Harry L. Bockus. He was a male, aged fifty-two, complaining chiefly of marked constipation, cathartic habit (cascara) of twenty-two years' standing. Occasional blood in the stools. Sigmoidoscopic examination revealed a chronic follicular colitis and multiple polyps. Polyps in the sigmoid, pelvic and transverse segments were discernible in other double contrast roentgenograms taken with the patient in the lateral recumbent positions.

FIG. 3*a*. Double contrast roentgenogram. Normal colon with residue in the upper descending and rectal segments. Dense marginal linear density outlines the entire colon. This line is thinnest in the ceco-colon where the fecal column is more liquid so that after the evacuation the residuum of barium sulphate suspension clinging to the mucosa is almost completely washed away.

tinct or invisible. If the walls of the colon are coated with a thin film of a densely opaque residue of barium sulphate, air can then be strikingly used as the second contrast medium so that one can readily visualize the entire outline of the colon, no matter how redundant or reduplicated it may be. If, in addition, the colon is not completely evacuated of the barium sulphate enema, then the residual fluid levels again further aid in the study of the colonic margins in the detection of intraluminal protrusions or excrescences.

The technique of examination with the double contrast enema as we employ it is somewhat different from that recommended by Fischer. He insists that only horizontally directed roentgen rays be used and that the barium suspension used in the single contrast enema preceding the air insufflation should not be completely evacuated, so that fluid levels are always present for guidance and study in the double contrast roentgenograms. This necessitates examination of the patient in the erect and lateral recumbent positions on each side. We allow our patients to completely evacuate the colon if possible and use vertically directed roentgen rays with the patient in the prone or supine position in making the double contrast roentgenograms. If evacuation is incomplete, however, after the initial single contrast study then we revert to Fischer's method. Our method, therefore, is to simply make a single contrast barium enema examination as is generally carried out using the usual barium sulphate suspension in warm water with or without kaolin. The injection is, of course, done under roentgenoscopic control and, after complete filling and study of the colon, roentgenograms are made. The patient is then allowed to evacuate the colonic contents normally, after which he is again immediately roentgenoscoped. Note

FIG. 3*b*. Double contrast roentgenogram. An irritable colon commonly referred to as muco-spastic colitis in a patient with chronic constipation and a long-standing cathartic habit. Note the irregularity of the residual coating of barium on the mucosa and the stringy mucus in the transverse colon.

is made of the amount and location of any residual contents. Palpation is also done again at this time since irritable colonic segments are often uncovered, as can be determined by the presence of mass hyperperistalsis, spasm, pain and tenderness. Mass hyperperistalsis is uncovered during this phase of the examination more frequently than at any other time. Its significance, however, must be carefully interpreted since it need not necessarily be abnormal. If unusual roentgenoscopic findings are made at this time, roentgenograms are taken again. If too much of the residual contents is present, the patient is asked to spend more time in further evacuation. The last phase of the examination is then carried out by simply inflating air into the colon with a Pulitzer bag of 400 c.c. capacity bearing a ball valve in the bulb. This mechanism is sufficient to prohibit back-wash from the rectum as the bulb refills itself with room air. The Pulitzer bag is attached to an 18-inch length of flexible rubber tubing, to the other end of which is attached an ordinary hard rubber rectal nozzle. No double tandem rubber bulbs with petcocks between them to prevent back-wash are used as described by Fischer. If the Pulitzer bag is held about 18 inches above the level of the colon and is fitted with a ball valve mechanism so that air from the room flows into the bulb easily with release of pressure, practically no back-wash into the inflating apparatus takes place and the procedure is thus much simplified.

FIG. 3c. Double contrast roentgenogram. A true acute nonspecific colitis in a patient with diarrhea, four bowel movements daily at time of examination. Note *absence* of dense linear marginal colonic outline and residual mucosal film of barium suspension.

FIG. 3d. Double contrast roentgenogram. Chronic ulcerative colitis. Note besides the usual changes in the colonic outline and contour, an orange-skin-like dimpling of the mucosa and beading of the margins.

We have carried out this examination in over 2,000 cases, in normal, as well as in all sorts of pathological conditions, and this includes several cases of chronic ulcerative colitis in stages of acute exacerbation. We have never encountered any ill effects worse than those usually caused by the ordinary single contrast enema. One must remember, however, that air inflation is

done slowly. The pressure should never be too forceful and this is easily regulated because the Pulitzer bag is held in the examiner's hand and he can directly feel the pressure. The entire filling is checked by proper roentgenoscopic control so that when the colon is filled, but not distended, air inflation is stopped. We measure the quantity of original barium sulphate suspension used in the first part of the study and never exceed this amount with inflated air in the last phase of the study. The quantity necessary is usually between 800 to 1,400 c.c. of air; usually much less in old cases of chronic ulcerative colitis and much more in long redundant capacious colons.

ERRORS CORRECTED DUE TO INCOMPLETE FILLING, LOCAL SPASM, MEMBRANES AND ADHESIONS

Some roentgenologists always insist on so-called proper preparation of the colon before carrying out the ordinary single contrast enema study. Usually a laxative the night before and a preliminary enema some hours before the examination are recommended. Other roentgenologists do not deem this preliminary preparation necessary. No matter what troublesome effort is made to obtain complete cleansing of the fecal material from the colon, many cases present themselves with filling defects noted most frequently in the cecum, ceco-colon and sigmoid, which are due to retained fecal material and which simulate true organic processes. Unless examination is repeated, the roentgenologist's opinion based on the single study is much vitiated. Sometimes even when the study is repeated, similar filling defects are again seen. If the single contrast examination is followed by the double contrast studies with the patient in at least two different positions, viz., in each lateral recumbent position, and the roentgen rays directed horizontally, then all question of error in

FIG. 3*e*. Hyperplastic ileocecal tuberculosis (single contrast roentgenogram). It is difficult to discern clearly the outline of the ileocecal area because of adhesions and overlapping by the inseparable loops of terminal ileum.

FIG. 3*f*. Double contrast enema study of the same case as in Figure 3*e*. Shortened, contracted, deformed cecum clearly seen. Hyperplastic filling defects are visible in the slight residual cecal contents. Ileocecal junction clearly seen and deformed terminal ileum easily distinguishable.

Fig. 4*a*. Diverticulosis lower descending colon, single contrast enema.

Fig. 4*b*. Same case, double contrast enema. Note visibility of diverticula on all surfaces of the circumference and the uniformity of the residual barium coating of the mucosa.

interpretation can usually be settled. If the defects are due to fecal material, then changes in their positions in the colon and in their contours become manifest in the double contrast roentgenograms. Spastic contraction of a segment of the colon occasionally causes uncertainty in interpretation in single contrast films, especially if they were not noted during the roentgenoscopic examination. This uncertainty, however, is quickly overcome if one has an additional set of double contrast roentgenograms as a check; not that spastic contraction of the segment is not occasionally seen in the double contrast films but only rarely is such spastic contraction seen in the same segment in both sets of films unless there is a real underlying organic lesion. When this is so, this lesion is usually better demonstrated in the double contrast roentgenograms. Jackson's membrane, Lane's kink and other congenital or old inflammatory adhesions are never actually visible but their presence is readily inferable when there is less than normal mobility in the involved colonic segments with inseparability of adjacent or abnormally placed segments. Once in a while, however, there is such matting and overlapping of colonic segments in veils or adhesions that no degree of rotation or palpation makes possible a satisfactory demonstration of the outlines and contours of the various involved segments. It is in such cases that the double contrast roentgenograms have real value, for no matter how duplicated or bound together the colonic segments may be, their outlines are always clearly traceable throughout, the fluid levels are always discernible and their restriction in mobility thus always readily determinable.

COLITIS, TRUE AND FALSE

The normal colon usually rids itself of 75 or 100 per cent of all the opaque contents used in the single contrast enema examination. If there is some residue present, it may usually be seen in the cecum or upper descending colon and occasionally in the sigmoid or rectum. In the double contrast roentgenograms, a thin film of residual barium suspension is seen on the

FIG. 4*c*. Diverticula visible in the descending and pelvic colons, single contrast enema.

FIG. 4*d*. Same case, double contrast enema. Note irregularity of residual barium coatings on the mucosa both of the colon and of many of the diverticula such as one sees in the milder forms of colitis. The same findings in the diverticula are taken as evidence of a mild diverticulitis, in addition to the other criteria used by Spriggs and Marxer. This patient had slight intermittent bleeding and diarrhea.

mucosa which gives the colonic outline a sharp, uniform, etched-like appearance against the denser intraluminal air zones. Besides all the other usual criteria used in establishing the diagnosis of so-called irritable colons, changes in the uniformity of the film-like coating of barium suspension on the colonic mucosa can also be used to determine different grades of irritability and actual inflammation. In the mildest forms one may see a broken continuity in the marginal outline and a plaque-like distribution of the residual film of barium on the colonic mucosa. In the more advanced stages of irritability, the distribution of this residual coating is more irregular, often assuming a mosaic or lace-like appearance. Later detached casts lying free in the lumen of the colon may be seen, or long strings of mucus, such as described by Crane, are discernible. When one deals with cases of true colitis one finds not only complete evacuation of the involved segments but also complete absence of the residual film of barium suspension from the colonic mucosa. True catarrhal or ulcerative inflammations of the colonic mucosa are accompanied by exudate as well as excessive transudative mucus. This causes a less viscous medium which does not adhere to the mucosa so that the barium suspension in the involved portion is completely washed away from the wall at the time of evacuation. The usual white line of the colonic margin and the faint gray homogeneous film of coating of the colonic mucosa is therefore absent in the inflamed segment. The colonic margin becomes barely visible and sometimes entirely invisible. If ulcers are present and the barium residue sticks to the necrotic surface or lodges under overhanging edges, their presence may then be ascertained. We have encountered this quite rarely, however, and it seems to occur much less frequently than one would expect. In chronic ulcerative colitis, besides the usual changes seen in this condition, one sees a

Fig. 5*a*. Intraluminal adenoma with short pedicle in the lower descending colon not visible in the single contrast roentgenograms.

characteristic distribution of the film of residue on the mucosa. There is a dimpled or grained appearance to the mucosa like the skin of an orange. The extent and distribution of ulceration in tuberculosis is better seen in the double contrast than in the single contrast roentgenograms and the hyperplasia seen in the hyperplastic types is more easily and clearly delineated as it is seen protruding into the air-filled lumen of the affected segment.[2]

DIVERTICULA AND DIVERTICULITIS

These are readily demonstrable by the usual barium enema studies. Spriggs and Marxer[3] have advanced what we believe are trustworthy roentgen signs in the diagnosis of prediverticulosis, diverticulosis and diverticulitis. The double contrast roentgenograms, however, yield some additional and confirmative evidence useful in the differentiation of these conditions. Not only are the marginal diverticula of the single contrast enema visualized but also those diverticula that may be present on all the remaining areas of the circumference of the lumen. One therefore gains a better idea as to the number and extent of diverticula present in any involved area. The presence or absence of inflammation in one or a group of diverticula is further ascertainable by applying the same criteria used in arriving at a diagnosis of inflammation of other parts of the colon (see under colitis).

NEOPLASMS

Neoplastic processes ordinarily demonstrable by the single contrast enema are usually no better and sometimes not so well exhibited when studied with the double contrast enema; but this observation pertains only to the moderately or far-advanced cases. The double contrast enema has its most valuable application in the detection of early intraluminal neoplastic processes when the single contrast enema

Fig. 5*b*. Growth clearly and sharply visible in the double contrast roentgenograms. This growth was removed by Dr. Moses Behrend at the Jewish Hospital and was found attached to a short pedicle and measured roughly 5 cm. in diameter. Its benignancy was confirmed at immediate microscopic examination.

completely fails us. Small fungating or papillary growths or polyps, for the most part extending into the lumen of the colon and producing no filling defects, are completely lost to view in the single contrast enema because they are completely surrounded and hidden by the dense opaque column of barium mixture. These polyps, small adenomas or early fungating neoplasms are readily discernible in the double contrast roentgenograms, standing out clearly as definitely delineated tumor shadows of varying degrees of increased density in the clear air zones between the sharply etched colonic walls. Malignancy is best treated by preventive measures and one of the possibilities now available to the surgeon in the fight against cancer is to deal adequately with all pathologic processes that are potentially malignant. Polyps, adenomas and other benign neoplastic growths in the colon are all potentially malignant, and more serious effort should be made to detect early their presence, and immediately eradicate them. The double contrast enema makes their early detection possible in the colon and when surgeons muster conviction enough to advise their immediate removal, a long step forward in the treatment of colonic cancer above the rectum will have been taken.

SUMMARY

1. The double contrast enema, as we apply it, aids in the roentgen diagnosis of spasms and adhesions of the colon; it makes possible elimination of errors in diagnosis due to filling defects, the result of incomplete filling and spasm.

2. It allows a more conclusive differentiation from the roentgen findings alone between irritable colon and so-called spastic colitis and true inflammatory and ulcerative colitis. It is a distinct advance in the roentgen diagnosis of ileocecal tuberculosis, simplifying greatly the procedure of study recommended thus far by the best investigators in this field who have been using the opaque medium by mouth. Additional roentgen signs are made available in the diagnosis of chronic ulcerative colitis.

3. Additional information is furnished by the double contrast roentgenograms in determining the actual number and extent of diverticula of the colon and the presence or absence of concomitant inflammatory changes in any of them.

4. Early neoplastic growths, long before they produce filling defects in the single contrast enema films, are detectable in the double contrast roentgenograms and open the way for the surgeon to go a step further, by their early removal, in the prevention of malignant degeneration.

5. The double contrast enema study is recommended as an additional routine examination to the ordinary enema study of the colon because it always furnishes a check duplicate study of the colon; it lends confirmatory aid and makes possible the detection of valuable supplementary findings in cases ordinarily studied with difficulty by the single contrast enema, and lastly, it makes possible the detection of lesions not suspected or demonstrable by the single contrast method alone.

We wish to express our appreciation to Dr. George E. Pfahler, vice-dean of the Department of Radiology in the Graduate School of Medicine, University of Pennsylvania, for the opportunity of making some of these studies in his department and to Dr. A. J. Cohen, director of Eagleville Sanatorium, for the opportunity of studying patients with suspected ileocecal tuberculosis at the Eagleville Sanatorium.

The material used for these studies was obtained from cases examined in the Roentgen-Ray Department of the Graduate Hospital, University of Pennsylvania, Eagleville Sanatorium for Consumptives at Eagleville, Pa., and from the authors' private practice.

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Vol. XXVII. No. 6

THE VISCOSITY OF LIPIODOL IN BRONCHOGRAPHY*†

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THE introduction of iodized oil as a diagnostic agent in roentgenography was, as Archibald and Brown[2] have pointed out, received with enough enthusiasm to delay the recognition of a number of disadvantages and dangers resulting from its use. The major ones have been enumerated by the aforementioned authors and a number of others. Besides the possibility of mishaps during or following the various technical procedures of the intratracheal injection, the danger of infection being carried by the oil into uninvolved parts of the lung has been discussed, and the possible unfavorable effect in the presence of tuberculosis in the lung has been particularly emphasized. The influence of lipiodol on pulmonary tuberculosis is discussed by me in a communication which is being published elsewhere.

The present article is intended to deal with some physical phenomena which, aside from infection, are responsible for diagnostic errors resulting from misinterpretation of roentgenograms of the chest after lipiodol injection. The possibility of such errors has been mentioned by others, particularly by Ballon and Ballon.[4]

Iodized oil is introduced for the purpose of outlining the bronchial tree and indicating defects in the lung parenchyma. After serving this purpose it is desirable that it be eliminated from the airways. (The therapeutic use of the oil will not be discussed here.) The elimination takes place quickly from the large and secondary bronchi where the cough reflex is strong, or from any large intrapulmonary cavity with wide bronchial communication. From small bronchial elements and the lung parenchyma it is eliminated with great difficulty, if at all. Yet it is the distribution of the oil in undiseased lung tissue which carries the possibility of infection and of diagnostic errors.[1,4,5,9] Two cases illustrating such errors are presented in the following:

CLINICAL CASES

CASE I (Fig. 1). E. J. Roentgenogram of the chest of a woman, aged twenty-five, with mild chronic pulmonary symptoms and a few physical signs, on the basis of which a minor bronchiectasis of the left lower lobe was suspected. The

Fig. 1. Case I.

stereoscopic films taken after injection of lipiodol were interpreted as showing extensive cavitation in the apex of the left lower lobe. At a later date the opinion was reached that there was no pulmonary involvement; the massive oil shadow adjoining the upper part of the heart outline was recognized as an area of normal lung tissue crowded with lipiodol.

CASE II (Fig. 2, A and B). L. T. Figure 2, A, taken immediately following lipiodol injection on October 21, 1929, shows minor bronchiec-

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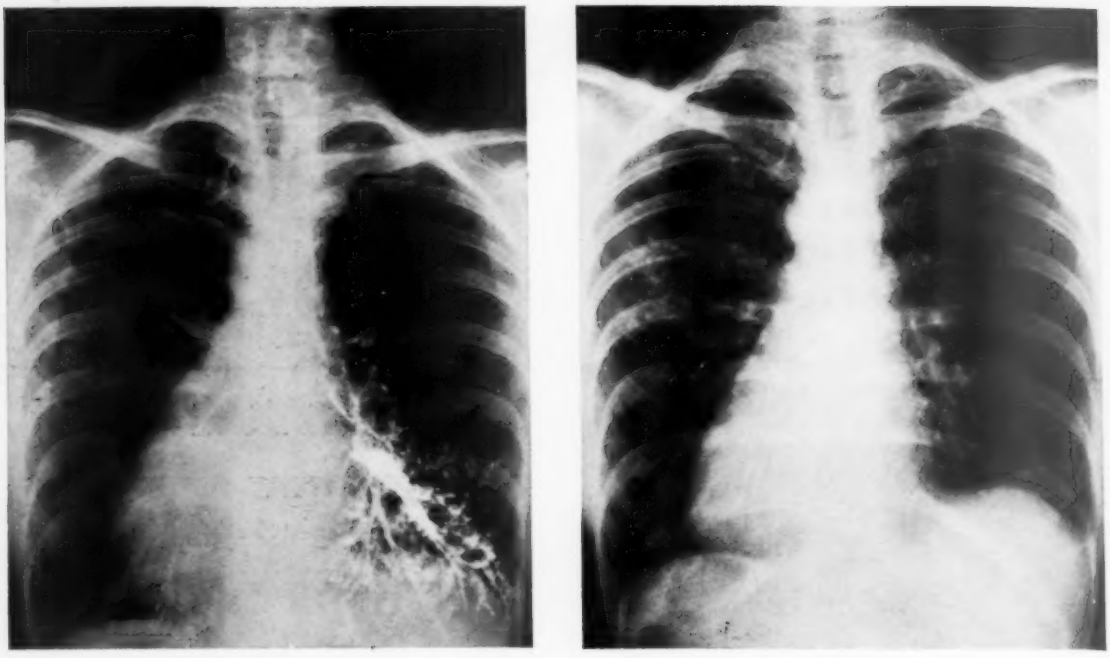
† My experience is limited to the use of the French preparation of iodized oil, Lipiodol Lafay. However, the experiments probably apply to a greater or lesser degree to other iodized oil preparations.



A B

Fig. 2. Case II.

tasis in the right lower lobe of a woman, aged forty. It should be noted that while there is a minimal, old fibroid tuberculosis in the apex of the right lung, the left lung field is entirely clear. Figure 2, B, was taken on June 9, 1930, more than seven months later. The previously injected area in the right lung shows the usual markings resulting from oil injection. In the left lung field there is a definite mottling near the periphery of the second and third anterior costal interspaces which was suspected as a tuberculous exacerbation, particularly as the patient had slight elevations of temperature and complained of unusual fatigue at that time. The symptoms were later recognized as being due to an intrauterine lesion and promptly disappeared after operative removal of the cause. There has been no recurrence of symptoms to date. The markings in the left lung had to be interpreted as caused by lipiodol aspirated from the right lung shortly after injection.

From a clinical experience of this kind, it seems highly undesirable that the lipiodol enter the normal lung parenchyma, not mentioning the fact that considerable amounts of oil are led away from their intended purpose and that dense parenchymatous fillings can obstruct the view of other parts of the pulmonary organ where a diagnosis is sought.

The outstanding physical property which makes lipiodol or any other contrast oil fit for endobronchial use is its viscosity. The viscosity is highly variable and depends largely upon the temperature of the oil. In view of this fact, it is rather surprising that no attempt has so far been made either to determine the exact viscosity at various temperatures or to point out the difference in the roentgenographic effect of the oil when injected at different temperatures.

Sicard and Forestier,[10] in their book, gave 35°–40°C. as the proper temperature for clinical use and in this were followed by all the other authors who wrote on the subject. Their reason apparently was that one could not do better than inject the oil at the temperature which it would be bound to assume shortly after injection. Before the justification of that assumption is discussed, it should be pointed out that probably in the majority of all clinical injec-

tions, 37°C. is not the temperature at the moment of the introduction of the oil. My observation in my own and other clinics has been that the determination of the temperature is a rather casual part of the procedure. Usually the oil container is put into a pail of hot water or a glass syringe containing the oil is heated over a flame until it reaches about body temperature. Ordinarily the only control is the immersion of a finger into the water bath, which test commonly results in an under-estimation of the temperature. Checking the temperatures in my clinic showed oil temperatures occasionally above 45°C. and almost always above 37°C. This, in connection with the great variability of the oil viscosity under the influence of changing temperature, seemed to demand a more accurate and experimental investigation.

EXPERIMENTS

Experiment 1 A: The viscosity of lipiodol (Lafay) was determined over a wide range of temperatures. This was accomplished by the method described by Gibson and Jacobs[8] in 1920. A small standard steel ball-bearing (0.15 cm. diameter) is dropped into a standard tube containing the oil and the time taken for it to fall through a given distance is measured. (The customary method of employing a capillary tube could not be used because the oil would not pass through the tube.) The viscosity is expressed in C. G. S. (Centimeter-Gram-Second) units. The values from which the calculations were made are indicated in Table 1. The two extreme temperatures were 49°C. and 0.5°C.

TABLE I

VISCOSITY OF LIPIODOL

Temperature	Time of fall in seconds	Height of liquid in tube in cm.	Density of liquid gm./c.c.	Viscosity in C.G.S. units
49.5°C.	4.2	26.1	1.317	2.23
37.0°C.	8.0	25.8	1.328	3.70
25.5°C.	15.7	25.5	1.338	7.62
17.8°C.	29.2	25.5	1.344	13.85
0.5°C.	56.7	22.5	1.359	27.2

The wide range even between the values found at temperatures fit for clinical use, namely, from about 18°C. to 37°C. should be noted.

Fig. 3.

Experiment 1 B: This experiment was undertaken to demonstrate approximately the behavior of the oil in the trachea after injection at different temperatures. Equal amounts of lipiodol were cooled or heated to four different temperatures, three of which were again those considered of clinical importance. The oil-filled test tubes were then drained simultaneously into moderately inclined cardboard channels. The photograph reproduced in Figure 3 shows the widely differing velocity of flow of oil in the four channels.

Experiment 2: Figure 4 shows the chest films of two large rabbits which were injected with lipiodol at two fairly extreme temperatures, about 6.5°C. in Rabbit A and at about 45°C. in Rabbit B. Equal amounts of 3 c.c. each were injected into the trachea of the animals but about ¼ of the amount was expectorated or swallowed by Rabbit A before the introduction of the highly viscous oil was completed. However, the unequal amounts of oil could not account for the striking difference in the roentgenographic appearance. The cold lipiodol shows a very satisfactory outline of the tracheobronchial tree while the warm oil

caused a diffuse and patchy parenchymatous infiltration obscuring the bronchial outlines.

Experiment 3: Lipiodol was injected at temperatures which were found to be within the range of clinical application. Three rabbits were injected intratracheally with 1 c.c. of lipiodol. An attempt was made to get it to run into one side only by proper position. The temperatures of the oils were:

Rabbit A 18°C.
Rabbit B 25°C.
Rabbit C 37°C.

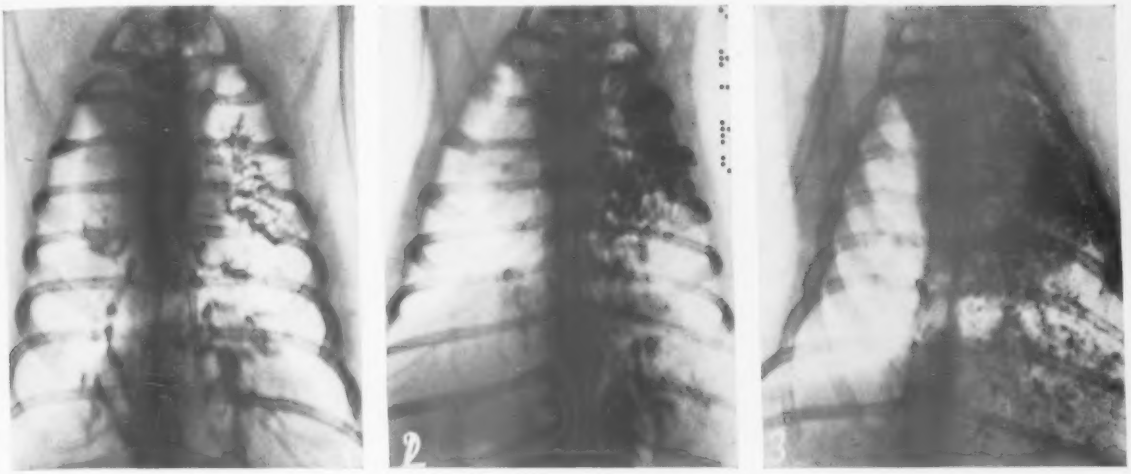
Within this narrower temperature range the differences of the roentgenographic effect can still be easily recognized (Fig. 5). In Rabbit A only the bronchial tree is outlined, while in Rabbit B there is a definite parenchymatous filling. This is still more pronounced in Rabbit C, where an area in the central lung field nearly reaches the density of the oil crowded area shown on the patient's roentgenogram in Figure 1.

COMMENTS AND SUGGESTIONS

It should be pointed out that to some extent the intratracheally injected oils choose their own route. Fluids, particularly those of a high viscosity, have a tendency to let the first drop lead the way and that first drop, influenced by peculiarities of the road-bed may take a somewhat unexpected course. Thus, during the actual injection, the flow of a considerable portion of the oil may not be quite in accord with the desire of the operator when he places the patient in a position thought to be most favorable for filling one particular part of the bronchial tree. On its way down the self-confined rivulet of oil may encounter the opening of a wide bronchus and follow it before it ever comes near its destination. It is a common experience that the basal parts of a lower lobe, suspected of being the seat of a pathological process, bronchiectasis for instance, does not fill properly with the oil although the upper

A B

Fig. 4.



A B C

Fig. 5.

portion of that lobe is crowded with it. A lower temperature, and thereby a higher viscosity, undoubtedly increases this tendency, but in clinical practice it is probably not important enough to outweigh the undesirable effect of parenchymatous fillings illustrated by the above reports and experiments. Those, I believe, amply demonstrate the necessity of temperature control in endobronchial contrast oil injections.

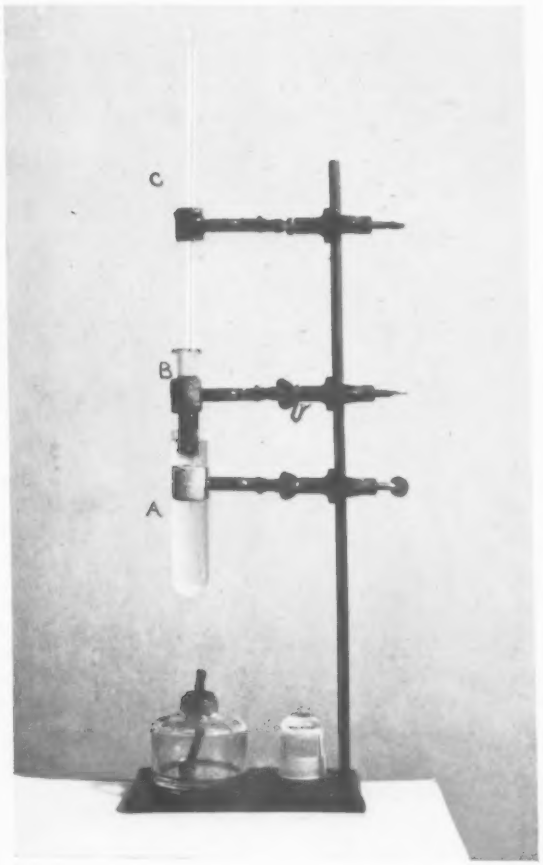


Fig. 6.

The oil, of course, assumes body temperature soon after injection. However, it has ample time to spoil the expected roentgenographic effect before the temperature change is completed. If injected too cold, it will irritate the large bronchi so violently that it is coughed up before ever reaching a secondary bronchus. At uncontrolled warm temperatures it will quickly travel far down into the small bronchi from where a cough reflex does not originate and is aspirated into the alveolar spaces by unduly deep inspirations during the operation, particularly by those preceding or following cough.

The range of temperatures at which lipiodol is injected, therefore, should be definitely limited. The animal experiment recorded in Figure 5 shows that 37°C. is really not the ideal temperature but definitely involves the possibility of undesired alveolar space fillings, and that the proper temperature is considerably below this. Judging from my experience, the oil should be injected at between 20°C. and 25°C.,

particularly when an outline of the bronchial tree only is desired. Down to 20°C. the oil is warm enough not to irritate the upper airways and the flow occurs with sufficient slowness. Alveolar filling and roentgenographic after-effects in the lung field will thereby be largely avoided.

A simple apparatus for accurate control of the oil temperature in clinical use is shown in Figure 6. The syringe (B) containing the lipiodol is immersed in a water bath (A). A thermometer (C) is placed in the oil. The piston of the syringe is removed; a styleted needle prevents the oil from running out into the water bath. The temperature is kept at the desired level until the operator is ready to make the injection.

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Vol. XXVII, No. 6

A ROENTGENOGRAPHIC STUDY OF GLASS AND ITS VISIBILITY AS A FOREIGN BODY

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ALTHOUGH fragments of glass are frequently embedded in tissues as foreign bodies, very little study has been made of the roentgenologic visibility of the various kinds of this substance.

A careful search of the medical indices reveals no reference to the use of roentgen rays for localization and identification of different types of glass embedded in the tissues of the human body. Likewise the literature on the localization of foreign bodies in general is singularly silent concerning glass, though much has been written on the roentgenological localization of metals such as bullets, shrapnel, etc., and of a variety of small objects that can be swallowed or inhaled. A number of methods have been devised for the accurate localization of such bodies by mathematical formulae, but few cases seem to be recorded in which the roentgen rays have revealed a glass object embedded in the tissues.

PREVIOUS REPORTS

Relhef,[1] in 1928, described the case of a young man who, as the result of a fall from a stepladder, sustained a chest injury, breaking two ribs. Later an abscess formed, which was opened and drained by the insertion of a glass tube. Within a few days the patient developed more serious symptoms than he had hitherto shown. A roentgenogram of the chest revealed the glass drainage tube in the upper left lobe of the lung between the dislocated ribs. Relhef states that he has been unable to find any similar case in the literature, except one reported in 1901 in which a tracheal cannula was swallowed.

Painchaud[2] has recently reported a case in which a glass bottle stopper was lodged in the trachea and located roentgenographically.

That so little mention is made of glass embedded in the tissues and its localization by means of roentgen rays is rather strange in view of the frequency with which accidents result in injuries being inflicted by broken glass. It is also surprising in view of the fact that, over a considerable period of years, much has been known of the variable transparency to light rays of different types of glass.

Kaye[3] writes as follows:

> Schott, in 1899, was the first to make up a glass of this kind (one transparent to the x-rays)—silico borate of soda and aluminum, as the result of experiments on the transparency of various oxides and carbonates to the x-rays. His list reads in the order of diminished transparency: Lithium, boron, sodium, magnesium, aluminum, silicon, potassium, copper, manganese, arsenic, barium, lead, a sequence which is that of the atomic weights of these substances. In 1906, C. E. S. Phillips made a conducting glass, which is a mixture of silicate of soda and borax with a little lead glass, which is very transparent to the x-rays. Lindemann (1911) was the first to construct focus bulbs provided with windows of a glass of lithium borate, which of all the glasses ever made is the most transparent to soft x-rays.

EFFECT OF KIND OF GLASS ON VISIBILITY

From my review of the literature it appears that no study has hitherto been reported of the absorption of roentgen rays by various types of glass, that is, of the density of the shadows these types of glass cast on a roentgen film. Neither has it been determined what expectation one might have of demonstrating roentgenologically the presence of glass of different types and sizes lodged as foreign bodies in the tissues or cavities of the body.

To determine these important facts, the following investigation was carried out:

Specimens of seventeen different types of glass were cut and ground to a uniform

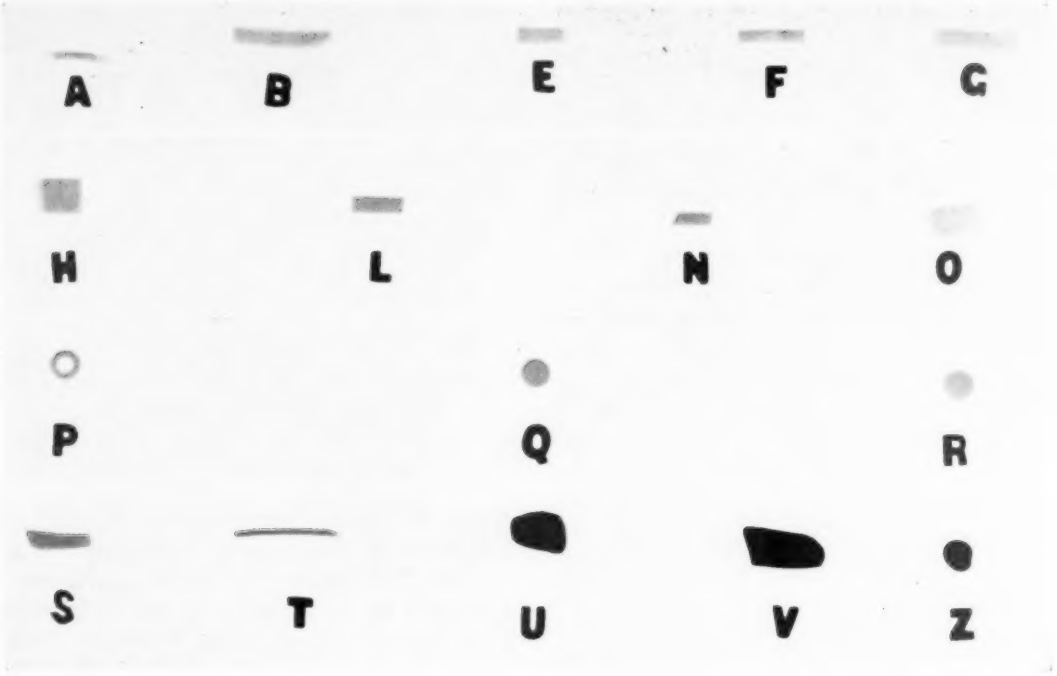

Fig. 1A. Roentgenogram of different types of glass, all specimens of 5 mm. thickness, using 3-inch spark gap, no intensifying screens, 1 mm. aluminum filter. *A*—White bottle glass. *B*—Milk bottle glass. *E*—Green bottle glass. *F*—Brown bottle glass. *G*—Blue bottle glass. *H*—Plate glass. *L*—Window glass (sheet glass). *N*—Vitaglass. *O*—Borosilicate glass (pyrex). *P*—Laboratory tubing glass. *Q*—Thermometer glass. *R*—Electric light bulb glass (lime glass). *S*—Optical glass (thick). *T*—Optical glass (thin). *U*—Barium glass. *V*—High lead glass. *Z*—Average lead glass (about 20 per cent).

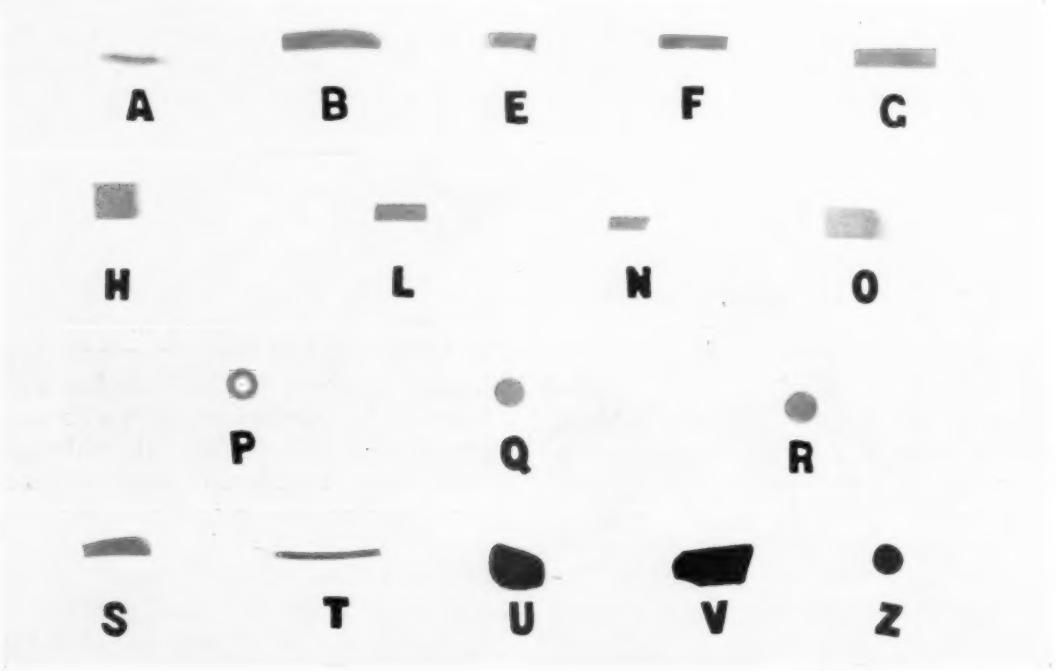

Fig. 1B. Same as Figure 1A, except made with 6-inch spark gap and double intensifying screens.

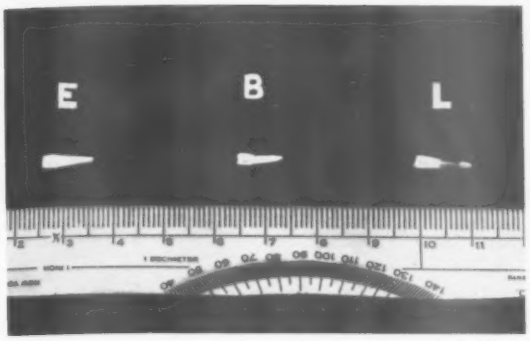

Fig. 2. Photograph of specimens of glass used in depth experiments, alongside a centimeter scale. *E*—Ordinary glass (soda-lime-silica glass). *B*—Barium glass. *L*—Lead glass.

thickness of 5 mm. Roentgenograms were made of these specimens, using qualities of rays at the limits of the range commonly employed in roentgen work, that is, a 3-inch gap and a 6-inch gap. No intensifying screens were used in the 3-inch gap exposure; double intensifying screens in the 6-inch gap. A 1 mm. aluminum filter was employed in both. The films are shown in Figures 1A and 1B.

It will be noted from Figure 1 that the

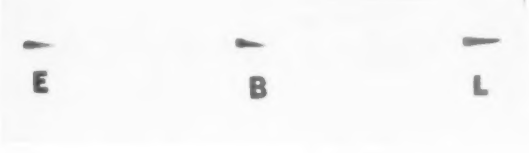

Fig. 3. Roentgenogram of specimens used in depth experiments. *E*—Ordinary glass (soda-lime-silica glass). *B*—Barium glass. *L*—Lead glass.

shadows of the pieces of glass up to the last three can be regarded for all practical purposes as of equal intensity. Twelve of these first fourteen specimens belong to the type of glass most frequently used commercially, the so-called soda-lime-silica glass, the principal ingredients of which are stated in the name. The thirteenth specimen, *O*, is borosilicate glass, called pyrex, and its density does not differ from the others. The fourteenth of these less dense glasses, *N*, is vitaglass. It is surprising, in view of its behavior to ultraviolet rays, that the transmission of roentgen rays through vitaglass proved no greater than through any of the other specimens used. So far as I have been able to determine, these are the first roentgenological tests ever reported with vitaglass.

Attention is called to the fact that the ingredients used in coloring glass (often heavy metals) seem to be present in too small quantities to affect appreciably the glass shadows.

The last three specimens shown in Figure 1 are much more dense than the preceding fourteen. Specimen *U* is barium glass; *V* high lead glass; and *Z* average lead glass

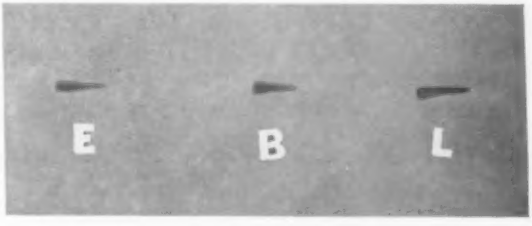

Fig. 4. Roentgenogram of specimens of glass through 4.5 cm. of paraffin, specimens 1.5 cm. from film; 3-inch spark gap used, 1 mm. aluminum filter, no intensifying screens. *E*—Ordinary glass. *B*—Barium glass. *L*—Lead glass.

(about 20 per cent). These three seem of about the same density, and no difference can be detected between the two lead glass samples with the quality and intensity of rays used.

From the viewpoint of the absorption of roentgen rays, we can therefore divide all glass tested into two groups: (1) the "or-

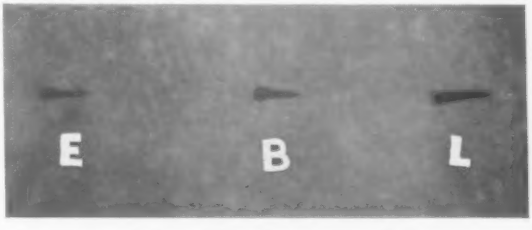

Fig. 5. Roentgenogram of specimens of glass through 7.5 cm. of paraffin, specimens 3 cm. from film; 3-inch spark gap used, 1 mm. aluminum filter, no intensifying screens. *E*—Ordinary glass. *B*—Barium glass. *L*—Lead glass.

dinary" glass (which we shall so designate in future for convenience), and (2) lead and barium glass.

Barium and lead glass have at the present time a very limited commercial use. The former is used, but infrequently, for optical purposes and for pressed ware. High lead glass is used only as protection against roentgen rays. Average lead glass is used sometimes for optical glass (though it must be remembered that many eyeglass lenses, including those examined in this investigation, contain no lead nor barium), for crystal table ware, for cut glass, and in art ware. It is also employed occasionally for tubing, thermometers, and electric light bulbs.

FIG. 6. Roentgenogram of specimens of glass through 12 cm. of paraffin, specimens 6 cm. from film; 5-inch spark gap used, 1 mm. aluminum filter, double intensifying screens. *E*—Ordinary glass. *B*—Barium glass. *L*—Lead glass.

But most of the glass belongs to the ordinary group, and practically all the glass which might be encountered as a foreign body—that is, window glass, automobile glass, a bottle fragment, clinical thermometer, etc.—falls into this class.

EFFECT OF DEPTH OF GLASS IN TISSUE ON VISIBILITY

The second part of this investigation was concerned with the determination of roentgen-ray visibility of small glass particles at different depths in the human body. For these experiments small, roughly conical specimens of ordinary glass, barium glass, and lead glass were prepared by cutting and grinding. These were fashioned to approximately the same size and shape, their base being about 2 mm. in diameter. Figure 2 is a photograph of these bits of glass alongside a centimeter scale, and Figure 3 is a roentgenogram of them. Blocks of paraffin, of which the atomic weight is about that of human soft tissues, were used to obtain various tissue thicknesses and various distances of the glass from the films.

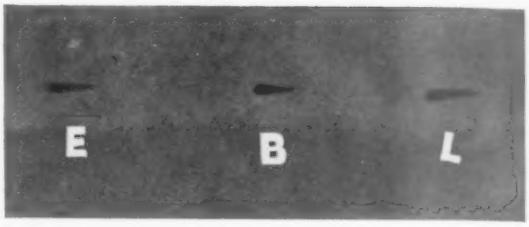

FIG. 7. Roentgenogram of specimens of glass through 18 cm. of paraffin, specimens 4.5 cm. from film; 5-inch spark gap used, 1 mm. aluminum filter, double intensifying screens. *E*—Ordinary glass. *B*—Barium glass. *L*—Lead glass.

From the roentgenograms of these experiments, shown in Figures 4 to 8 inclusive, it will be seen that the three specimens are clearly visible at various distances from the film and through various thicknesses of tissues up to 18 cm., at which depth the shadow of the ordinary glass becomes rather faint, though the images of the barium and lead glass are still sharp and distinct. Attention is called to the fact that in Figure 8 the specimens lie at the midpoint of the paraffin block 9 cm. away from the film, and that even the tiny sharp points of these small conical pieces of glass are visible.

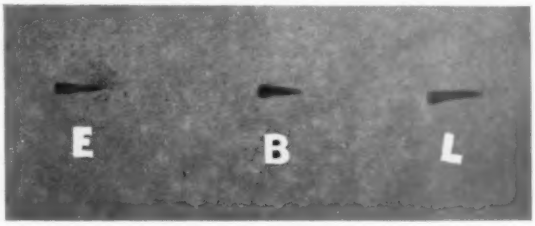

FIG. 8. Roentgenogram of specimens of glass through 18 cm. of paraffin, specimens 9 cm. from film; 5-inch spark gap used, 1 mm. aluminum filter, double intensifying screens. *E*—Ordinary glass. *B*—Barium glass. *L*—Lead glass.

SIGNIFICANCE OF FINDINGS

These experiments demonstrate that one might expect to show in films shadows of barium and lead glass particles even smaller than 2 mm. in diameter, lodged anywhere in the soft tissues of the body or in the body cavities, provided (1) that the films are made at various angles and in various directions so as to project the glass shadow clear of bone shadow, (2) that the intestinal densities are not too great and (3) that the patient is not exceptionally heavy. An absence of a glass shadow with these conditions fulfilled would seem to justify an opinion that no barium or lead glass is lodged in the part examined.

With regard to ordinary glass, findings should be quite conclusive through soft tissues as thick as an average shoulder or leg, and under favorable conditions through a thigh and even an abdomen or pelvis. But though our experimental films show the specimen distinctly through 18 cm. thickness, we cannot expect as perfect visibility in the living subject, for the soft tissues of the body are by no means as homogeneous as are the paraffin shadows.

SUMMARY AND CONCLUSIONS

1. Grouped according to the degree of its absorption of roentgen rays—that is, according to the density of its shadow on a roentgen film—glass falls into two classes: (1) "ordinary" glass and (2) lead and barium glass.

2. Lead and barium glass have limited commercial uses, most of which are mentioned.

3. A particle of lead or barium glass even smaller than 2 mm. in diameter, lodged anywhere in the soft tissues of the body, might be expected to be shown by a thorough roentgenographic study.

4. A particle of "ordinary" glass might be expected to be shown clearly in the soft tissues of the upper extremity or leg, and under favorable conditions in the thigh, abdomen, or pelvis.

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PRIMARY CARCINOMA OF THE LUNG

ROENTGEN DIAGNOSIS AND PRELIMINARY REPORT ON ROENTGEN THERAPY*

By WILLIS F. MANGES, M.D.
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PRIMARY bronchial carcinoma, like most other lesions presenting tissue changes, displacement of organs, and interference with function in the chest, comes into the field of roentgenology for diagnostic solution. The disease is either increasing or patients more generally are coming to the roentgenologist and bronchoscopist. Prior to 1924, very few cases are recorded in the Jefferson Hospital, but since then we have had an increasing number of proved cases and others lacking only the certainty obtained by biopsy or autopsy. I believe this is due to the fact that our internists and surgeons are sending more of their patients to the Roentgen-Ray Department for diagnostic aid. The Bronchoscopic Department has always sent all its cases to us. Everyone in the Roentgen-Ray Department is becoming more and more confident in his interpretations. At Jefferson Hospital we are all constantly thinking of this lesion as a possibility. The bronchoscopist is becoming more and more expert in obtaining tissue specimens for histologic study and he also acquires increased confidence in his opinion as to the nature of the lesions that compress bronchi from without. He has a sense of touch through his instrument so that rigidity, hardness, extent of compression, etc., become findings of importance when added to the roentgen-ray signs, the history, clinical findings and other laboratory data.

The thoracic surgeon is rapidly progressing in his art and not infrequently carries an important share of the diagnostic burden, as well as of the therapy burden.

The pathologist is, in the final analysis, the court of last appeal, and his decisions are almost universally in the nature of facts when he is given sufficient tissue for satisfactory study. Too often the tissue can only be obtained post mortem.

I believe it is safe to say that the diagnosis, as a rule, is not made until the lesion is well advanced. This seems true because our first roentgen examination in the vast majority of our proved cases shows either a large tumor mass, or atelectasis of a lobe or large portion of a lobe, or a large area of exudate-filled lung distal to the point where the growth obstructs a bronchus. In other words, the first roentgen examination reveals rather massive evidence of disease.

The reason for this is frequently reflected in the history. There is practically always a great deal of time between the onset of symptoms and the first roentgen study. In a very few instances the period of symptoms prior to roentgen study was quite brief. One patient had thoracic symptoms during only four weeks prior to positive diagnosis of adenocarcinoma. He also had a 4 plus Wassermann reaction.

This is certainly a disease that requires teamwork. In the first place, the general practitioner should always have in mind the possibility of this disease whenever there is evidence of persistent bronchial irritation or of bronchial obstruction. If he is not "carcinoma-minded," he will think of everything else but this, and for a long time. Then the medical consultant may or may not have such a possibility in mind. If he does, he will probably have a roentgen study made, and the extent, as well as the location, of the lesion is revealed. If it is within reach of the bronchoscopist, then under favorable conditions the lesion may be seen and tissue obtained for microscopic study. This latter procedure constitutes the only means of positive diagnosis ante mortem, except for the occasional case that

* Read at the Thirty-second Annual Meeting, American Roentgen Ray Society, Atlantic City, N. J., Sept. 22–25, 1931.

is found at the periphery of the lung instead of in one of the larger bronchi. In this location the surgeon may be able to obtain a specimen of tissue for study.

As stated by McCrae, Funk and Jackson[7]—"Early diagnosis should be made if the possibility of bronchial neoplasms is considered and careful studies are made. The early symptoms are usually those of bronchial irritation and the early signs

The first class is subject to positive diagnosis if in a bronchus or branch which can be seen through the bronchoscope.

In Class 2 the tumor can often be felt with the bronchoscope. Jackson uses the terms "fixity," "rigidity" and "deformity of the bronchial wall," and believes they are sufficiently characteristic features to justify a tentative diagnosis of malignancy.

In Class 3, when the lesion intrudes sufficiently, then again tissue can at times be obtained bronchoscopically.

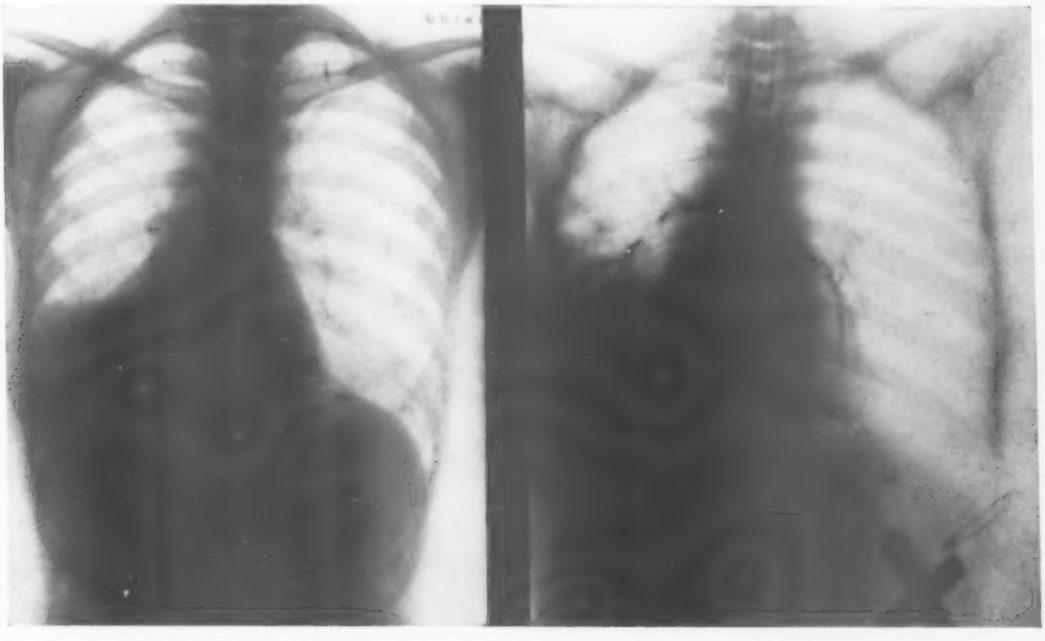

Fig. 1. Lesion involves the right lower lobe. Upper margin of dense area is sharp. The heart is displaced toward the lesion. Area of density medium-sized. Proved bronchoscopic biopsy. Note bismuth spreading over tumor in right lower lobe bronchus. Treated with roentgen radiation by Dr. Larkin. Patient alive and well more than eight years.

those of bronchial obstruction." These are the symptoms and signs of numerous other pulmonary conditions and will not lead to diagnosis of bronchial carcinoma unless the physician has it in his mind as a real possibility and sees that complete studies are made.

Chevalier Jackson[5] divides malignant growths of the lung into three classes: (1) Growths primarily endobronchial; (2) growths primarily peribronchial or parenchymal; (3) peribronchial growths seen after the endobronchial intrusion of the growth.

I am hoping that by a study of the roentgen appearances of proved cases, it may be possible to arrive at some fairly definite diagnostic conclusion in other similar cases that are not suitable for bronchoscopic or surgical biopsy. Also, I am hoping that those of you who have not seen many cases may profit by this analysis and become "primary-carcinoma-of-the-lung-minded." I want to emphasize this point: it is quite necessary for us as roentgenologists to keep this lesion in mind when there is evidence

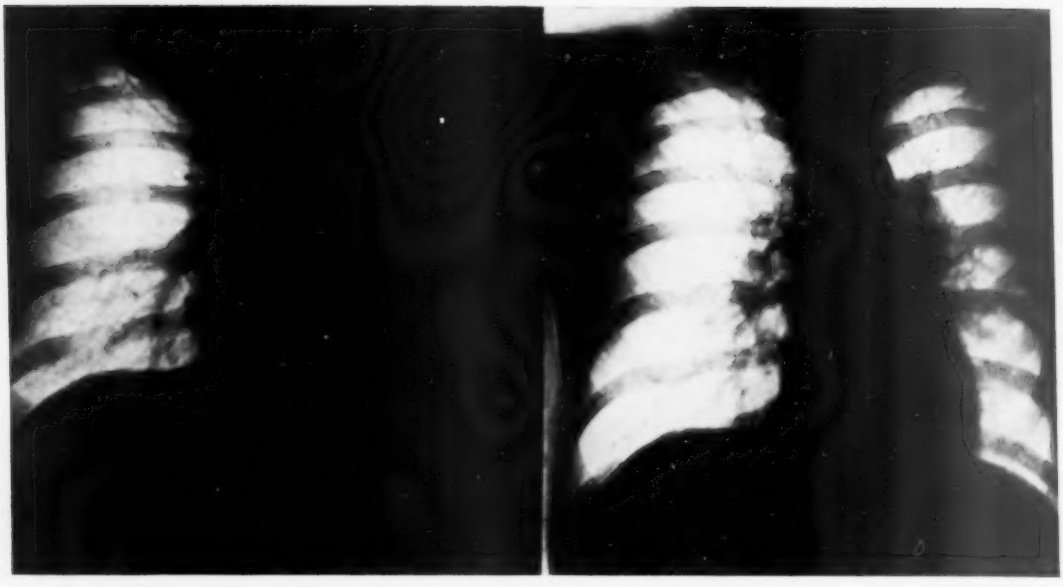

Fig. 2. Outline limited by the pleura. Heart displaced toward the lesion. Area of density large. Massive atelectasis, left lung, due to complete obstruction of main bronchus. After removal of tumor bronchoscopically, left lung functioned. Patient treated by Dr. Ashbury. Patient living more than four years.

of any lesion in the chest that is not recognized because it does not have an unmistakable or definitely characteristic appearance. This disease has no single characteristic roentgen sign. It appears in various locations, sizes, shapes and densities; involves small or large areas; causes varying amounts of displacement of organs,

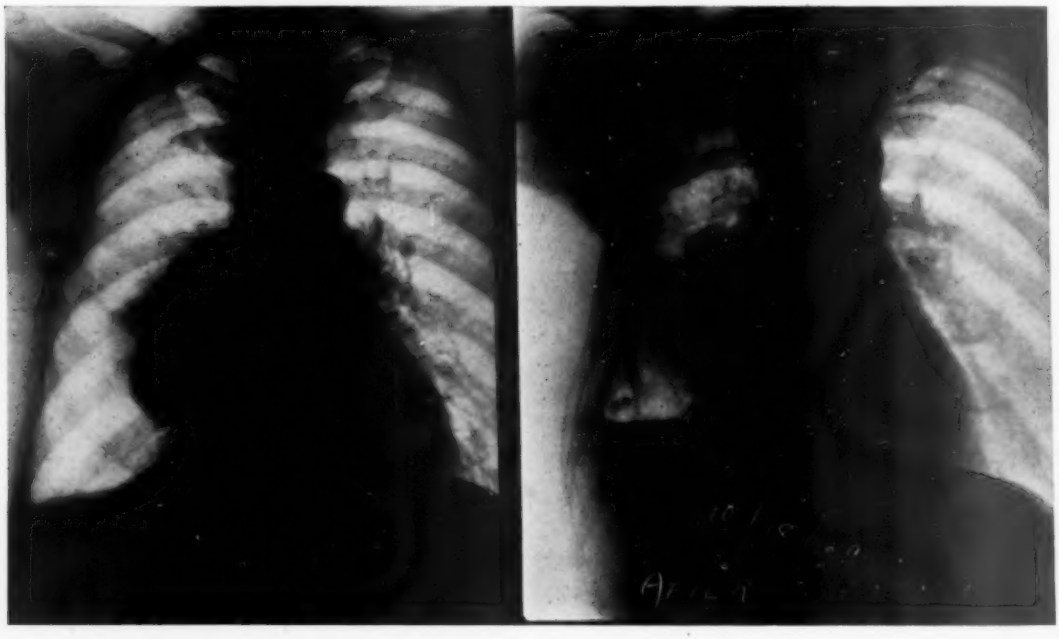

Fig. 3. Outline of mass sharply defined lower border; irregular upper border. The heart is displaced slightly away from the lesion. Mass of medium size and due to solid tumor mass rather than collapsed lung. Three months after treatment primary lesion smaller but lesion extends by way of the pleura.

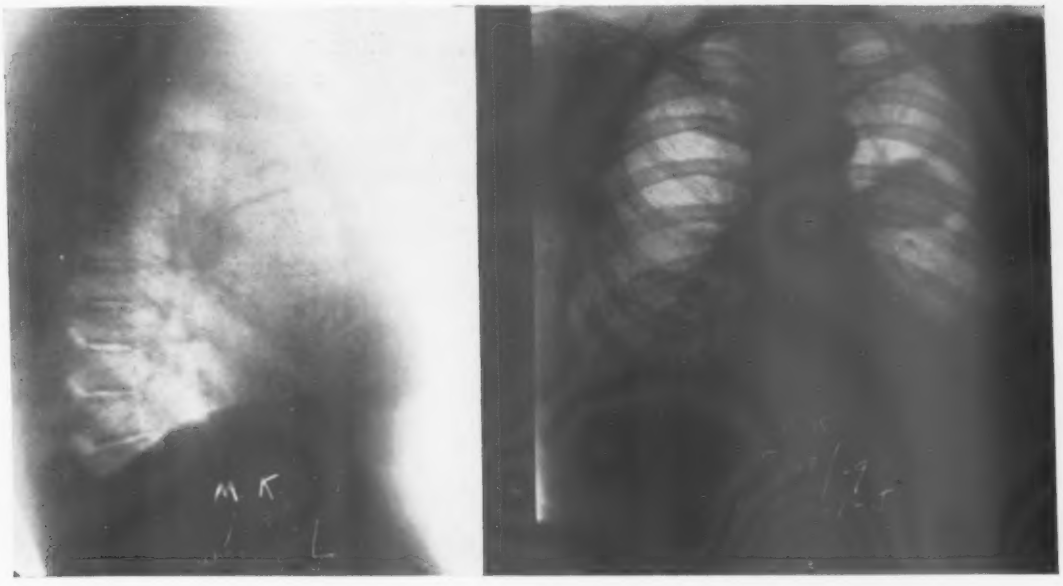

Fig. 4. Rather centrally located, sharply defined tumor. Note displacement of structures. Mass of small size. Patient living nearly three years after treatment. Mass still present, about three-fourths the original size.

different degrees of functional interference, at times out of all proportion to the size of the actual growth. The history and symptoms vary also. The lesion is frequently associated with infection which may be sufficiently active to draw all attention away from the idea of carcinoma. In one of our series of cases, the patient had been under bronchoscopic treatment for the lung abscess which it was evident he had, and finally had surgical interference for the purpose of getting satisfactory drainage, and

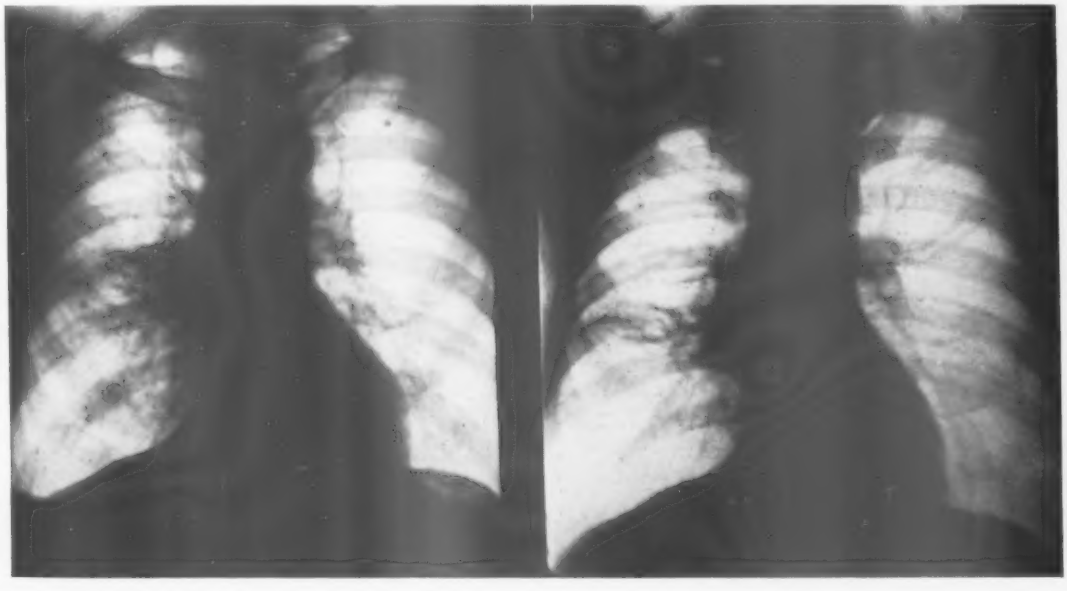

Fig. 5. The outline is very irregular. Practically no displacement of the heart. Area of density rather small. Patient lived approximately two years after treatment.

then later, because of unusual appearance in the wound, tissue was removed that was found to be squamous cell epithelioma.

I wish to direct your attention to a paper by Funk[3] on "The Clinical Manifestations of Primary Bronchial Carcinoma," the first paragraph of which reads as follows:

> This report is based on an analysis of the clinical features presented by sixty-one patients with primary carcinoma of the bronchus in whom the diagnosis was verified by histologic examination of tissue removed bronchoscopically (thirty-six cases), surgically (eight cases) or post mortem (twenty cases). In this group were fifty men and eleven women, a ratio of 4.5 men to 1 woman. The youngest patient was a woman, aged 24, and the oldest a man, aged 73. Only two patients were under 35 years of age (24 and 27). Twenty-seven patients (44.2 per cent) were between 35 and 45. The predominance among men, the incidence after the age of 35, and especially in the decade between 35 and 45, are factors of significance in diagnosis.

It will be noted that 20 of the 61 cases had positive tissue diagnoses only after death. This series probably represents an unusually high percentage of cases proved by tissue removed bronchoscopically because of the extreme efficiency of our Bronchoscopic Department at Jefferson Hospital, so that it is probably safe to say that fully one-third of the cases of primary carcinoma of the bronchus are not subject to ante-mortem diagnosis unless we can establish the ability to make such a diagnosis with a fair degree of certainty by means of the roentgen ray.

I have selected 36 of our cases for roentgenographic description and have tabulated them as follows: (1) as to the location, having reference to the lobe of the lung involved and as to whether or not the lesion was in contact with the root structures; (2) as to the outline of the area of tissue change, whether sharply defined on one or more surfaces or whether it was irregular in outline; (3) displacement of structures, either toward the lesion or away from the lesion; (4) as to the size of the area of abnormal density, whether large, medium or small; (5) as to whether there were roentgen evidences of metastases; (6) whether accompanied by other lesions or not; (7) whether proved by bronchoscopic biopsy, surgical biopsy, or post mortem; (8) as to whether or not there was involvement of the pleura; (9) as to whether or not they were treated with roentgen radiation.

As a result of this analysis, we find that 8 were in the right upper lobe, 5 in the right middle lobe, 8 in the right lower lobe, and 9 in the left lower lobe. Most of these also involved the root structures. Of those involving the root structures, 9 were on the left side and 15 on the right side.

The outline was sharp in 23 cases and irregular in 13.

Twenty-six showed some evidence of displacement of the heart and other mediastinal structures toward the side of the lesion; 3 showed evidence of displacement to the side away from the lesion; 7 cases showed practically no displacement.

In 21 cases the area was large, in 9 cases medium, and in 6 small.

Metastases were evident in 6 cases; no metastases evident in 30.

There were other lesions in 4 cases, such as lung abscess, or bronchiectasis, or lues.

There was bronchoscopic evidence of new growth in 29 cases but in a number of these the tissue removed was either insufficient for positive diagnosis or the records are indefinite. There was surgical biopsy confirmation in 3 and post-mortem confirmation in 5.

The pleura was involved in 6 cases and not involved in 30.

Twenty-one of the cases received roentgen treatment; 15 of this selected group did not.

I want to make clear the meaning of the terms that I have used. The outline, for instance, refers to that portion of the lesion which is in contact with normal lung tissue. If an entire lung is involved in the density, then the outline is sharp because it is limited by the mediastinal pleura. If a lobe

is collapsed, the upper or lower border of the mass of density will be apt to be sharp because, again, it is limited by the pleura. A tumor occupying the extreme upper portion of the lung may have a sharp lower border of the tumor itself rather than a sharp border of collapsed lung, or a tumor that stands out in a solitary fashion has a sharp outline on all of its surfaces. The outline is irregular when irregular portions of the lobe are involved in either an infiltrating process or when only small areas of lung tissue are collapsed or where there is irregular destruction of tissue due to concurrent infection. In a few of the cases the tumor mass was very small, radiated very much and produced relatively little displacement. In such cases, the outline, of course, is irregular.

By displacement, we mean that the heart or aorta, or the trachea, or the diaphragm, or all of these, have gone to one or the other side of the chest. In the vast majority of instances it is toward the side of the lesion. With displacement of structures there is also a definite interference with function in that there is less excursion of the affected diaphragm and less expansion of the chest wall on that side. This displacement at times is striking; again, it is very slight, for in 6 cases we could not determine that there was displacement, even though there was considerable size to the lesion.

In the size of the dense area, we include, of course, the collapsed lung, the exudate-filled lung, exudate in the pleural cavity, and this area is large, medium or small. By large, we mean that there is complete density over an entire three-fourths or half of it; by medium size, we mean one-fourth of a lobe or a mass the size of an orange or a little larger; and by small, we mean the small, isolated density that we have recorded in only 6 of these 36 cases. It is this phase of the study which I particularly want to emphasize. These massive densities are in themselves not unlike massive densities due to other lesions. It is true that even with these massive areas of density, including half of the chest, the displacement of the mediastinal structures is seldom away from the side of the lesion. It occurs only when there is a large amount of fluid in the pleural cavity. This massive density may be produced by a very small growth completely obliterating a main bronchus, or the growth may, by pressure from without, completely occlude the bronchus and produce collapse, in which case the growth may be of considerable size. If such lesions involve smaller bronchi, then smaller areas of lung are collapsed. It is common that infection develops distal to such obstruction and a great deal of exudate may collect and be retained in a lung in this way, so that, while at first there is collapse and retraction of the mediastinal structures, later with the increase in the collection of exudate, the displacement subsides, and occasionally the heart may actually go toward the unaffected side. This sign of displacement was first mentioned by Golden,[4] and he also brought out the fact that the pleura is frequently involved.

The cases showing moderate-sized areas of density may actually have larger growths than some of those showing massive densities, but in such cases the growth itself provides the dense shadow, or the lesion is distinctly infiltrating along bronchi perhaps, producing small areas of collapse or exudate rather than larger areas.

Those cases showing only small areas of variation from the normal densities are the very few that I believe are diagnosed early. We have seen a few of these progress from small to larger areas, and of these few some were treated cases and others were not.

Metastatic evidence was present in the chest in very few cases. In one of these it developed while the patient showed rather definite improvement, both clinically and as shown by the roentgenograms, as the result of roentgen treatment. In a few of the cases metastases in other organs were found post mortem, but our group of cases showed relatively few instances of metas-

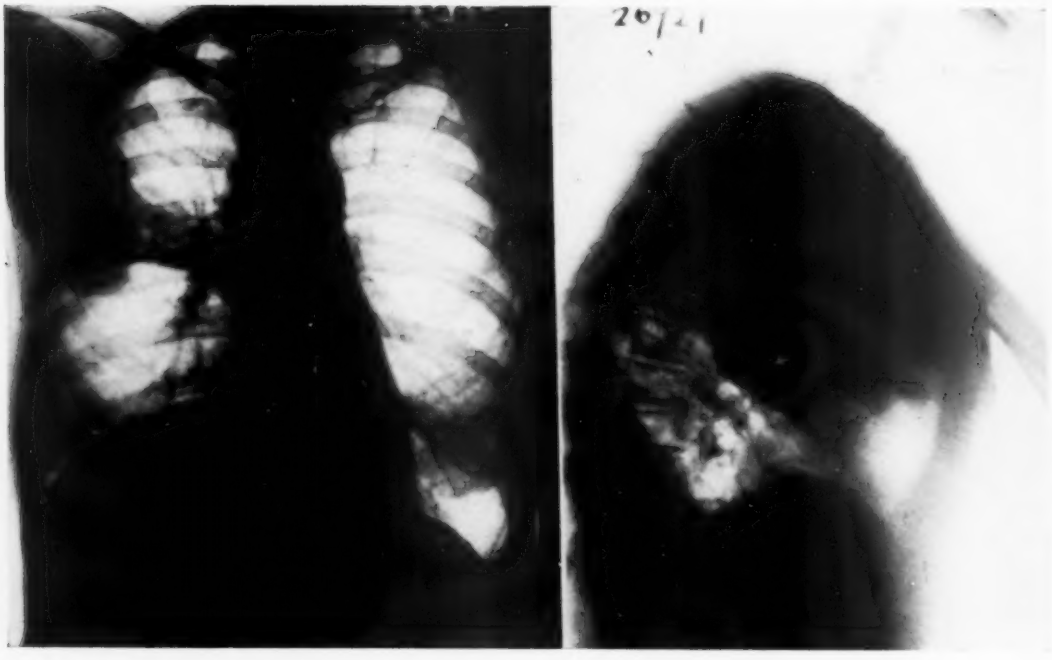

Fig. 6. Mass in contact with chest wall; has sharply defined borders. Right diaphragm markedly elevated. Involvement of the pleura between upper and middle lobes. Proved by surgical biopsy.

tases while under our observation or in our autopsy room.

Associated with carcinoma, a few of our cases had such lesions as lung abscess, bronchiectasis, and in 2 cases 4 plus Wassermann reactions. In both of these, the evidence of carcinoma was obtained post mortem, and also in one of the two by bronchoscopic biopsy. In a rather large percentage of the cases the bronchoscopist reported evidence

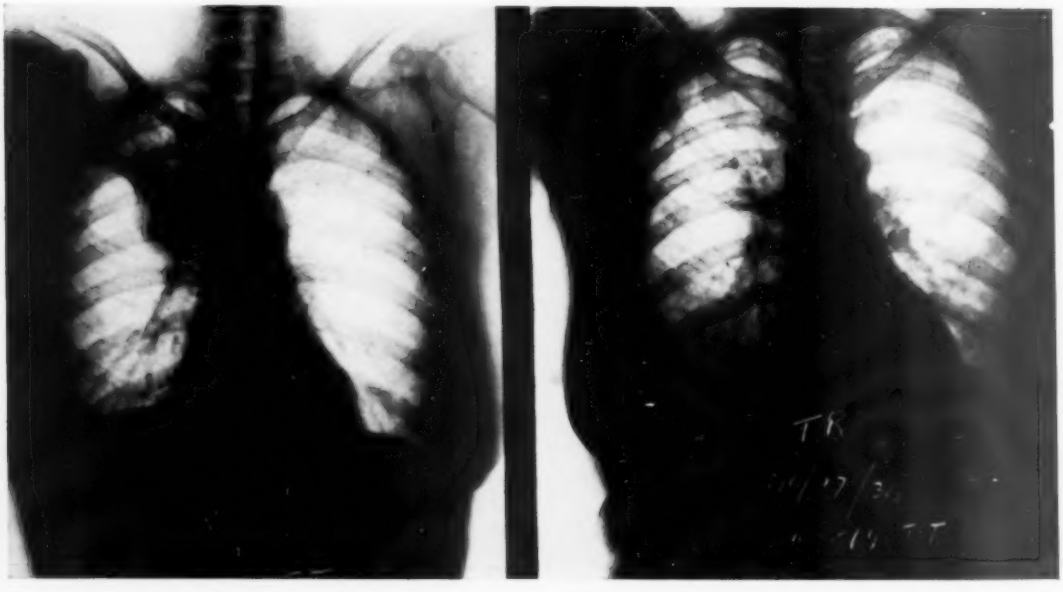

Fig. 7. Sharply defined lower border. Pleural involvement. Slight elevation, right diaphragm. Tumor almost disappeared within two months after treatment.

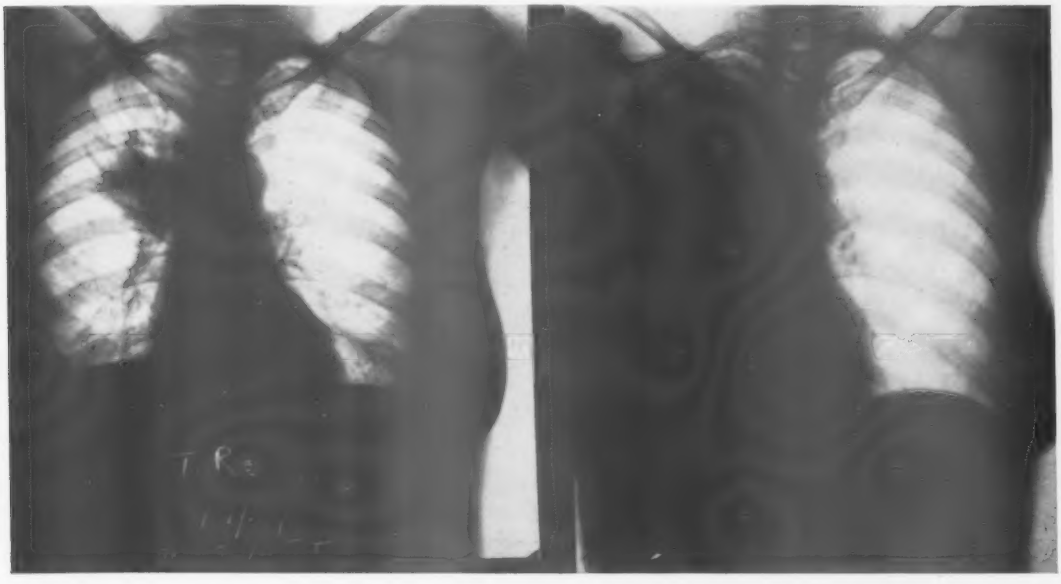

Fig. 8. Same case as in Figure 7. Lesion recurred. Note again slight elevation of right diaphragm; slight displacement of heart to right. This tumor is compressing smaller bronchi at this stage. Three months later entire right lung collapsed because growth compressed completely the right main bronchus. Note displacement of heart and trachea.

of purulent exudate, so that infection is rather common.

The one step that has brought this disease to light more than any other has been the obtaining of tissue from the bronchi through the bronchoscope. This should

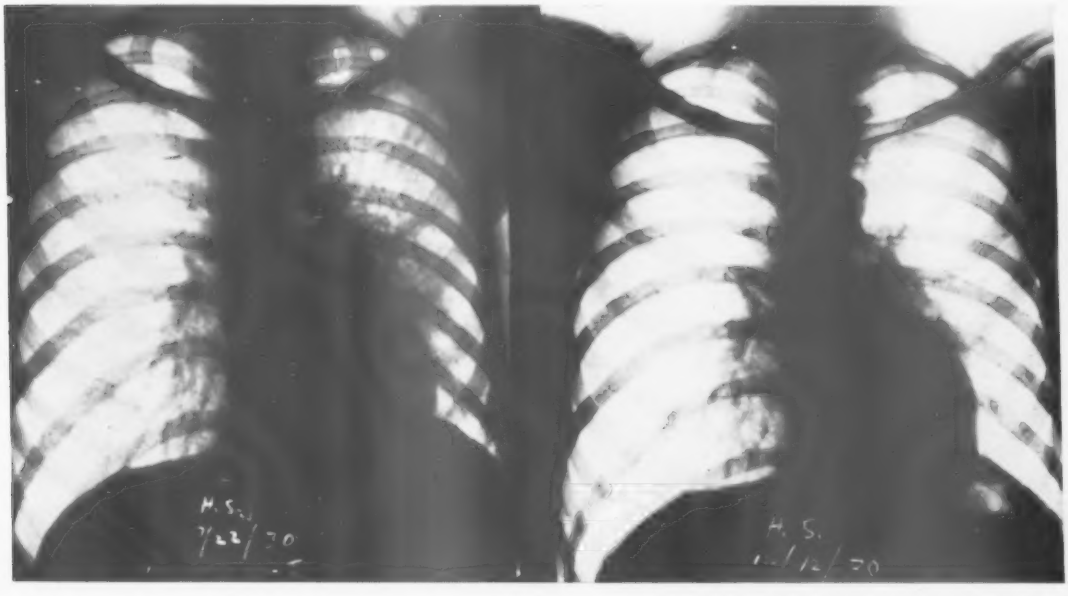

Fig. 9. Lesion involves the left upper lobe bronchi. Roentgenographically looks not unlike a tuberculous lesion. Outline is very irregular. The heart and trachea definitely displaced; left diaphragm elevated. The size of the area is indefinitely medium size. Bronchoscopic biopsy positive. Note that there is slightly less displacement of the heart and slightly less elevation of the diaphragm following treatment. Patient still living and symptom-free.

never be omitted when the lesion is at all within reach, not only because it removes any doubt when successful, but I have never observed that the procedure has done the least harm to the patient. Comparatively few of these growths are near enough to the surface for the surgeon to investigate without rather radical procedures, but when they are so accessible, it is a worth-while method. When there is fluid in the pleural cavity and it is found to be sanguineous, we consider it very strong corroborative evidence of malignancy extended to the pleura.

There is a remarkable similarity in roentgenographic appearance in the proved cases, regardless of the method of proof.

Our treated cases have shown remarkable variation in the way of improvement. Practically all of them show at least temporary clinical evidence of improvement, and a few of them have lived a number of years. One patient is living and well, except for a permanent bronchiectasis, for seven years; another six; another treated elsewhere is well nearly eight years, and a number have gone symptom-free for more than one year. A few of the advanced cases have shown only temporary improvement and then rapid progress. I believe that the manner in which they respond to treatment presents evidence of definite diagnostic value.

I know of no other chest lesion in which it is so important to know something of the history, clinical signs and symptoms. Quoting Funk again, in his clinical study of 61 cases, he noted the following facts:

> The relative frequency of the local symptoms in sixty-one patients was as follows: cough, 88 per cent; expectoration, 67 per cent; pain, 72 per cent; hemoptysis, 45 per cent; dyspnea, 50 per cent. The general symptoms of weakness and loss of weight follow, as a rule, the occurrence of the local symptoms and were sufficiently evident as to be noted as a part of the present illness by the patient in 80 per cent of the cases.
>
> Fever was present in 55 per cent of the sixty-one patients at some time.

In this analysis I have avoided a classification of the lesions into bronchial and parenchymal, as has been done by most writers and which has definite evidence of merit, particularly in the article by Kirklin and Paterson.[6] I believe it is unnecessary and perhaps unwise as well because even the pathologist, after autopsy, has difficulty at times in determining the exact origin of the lesion. The most important single object to accomplish is to determine whether or not the lesion is accessible to the bronchoscope, on the one hand, or to the surgeon, on the other hand. The results of bronchoscopy are so satisfactory that it is wrong to try to conclude the diagnosis without its help. Clerf[1] has gone so far as to say: "Next to its usefulness in foreign bodies in the air passages, bronchoscopy has developed its greatest value in the diagnosis of malignancy of the lung." While bronchoscopy is perhaps not a widely practised specialty, yet it has in the last few years made rapid strides and should receive every possible encouragement to develop still further. From the roentgenographic point of view, one must, of course, consider differential diagnosis. Of all the lesions in the chest, primary carcinoma of the lung more frequently resembles some infectious process than anything else, and this includes both acute and chronic infections. It is the more difficult because infection is so frequently a part of primary carcinoma of the lung. It follows defective drainage and in numerous instances the infection has manifested acute symptoms. For instance, it is not uncommon to find relatively high leucocytosis. Fever is relatively common. The most dependable signs in such instances are that, in primary carcinoma, one or more borders of the lesion are in the majority of instances, smooth or sharp. That is rarely the case in infection. The mediastinal structures are usually displaced to the side of the lesion when malignancy is present. They never are in acute infections, and in chronic infections the lesion is, in the vast majority of instances, bilateral, unless it is due to foreign body of long sojourn or follows a

Fig. 10. At first, mass irregular; marked displacement to side of lesion. Following treatment, sharply defined mass appears; only slightly less displacement. This was positive for carcinoma-bronchoscopic biopsy. Patient also had a 4 plus Wassermann reaction. Symptoms present only four weeks.

lesion, such as post-tonsillectomic lung abscess. As I pointed out in a former paper,[8] a unilateral chronic lesion in the dependent portion of either lung must be considered evidence of chronic infection due to foreign body until it is proved to be due to something else. Since the histories of such infections carry over for long periods of time,

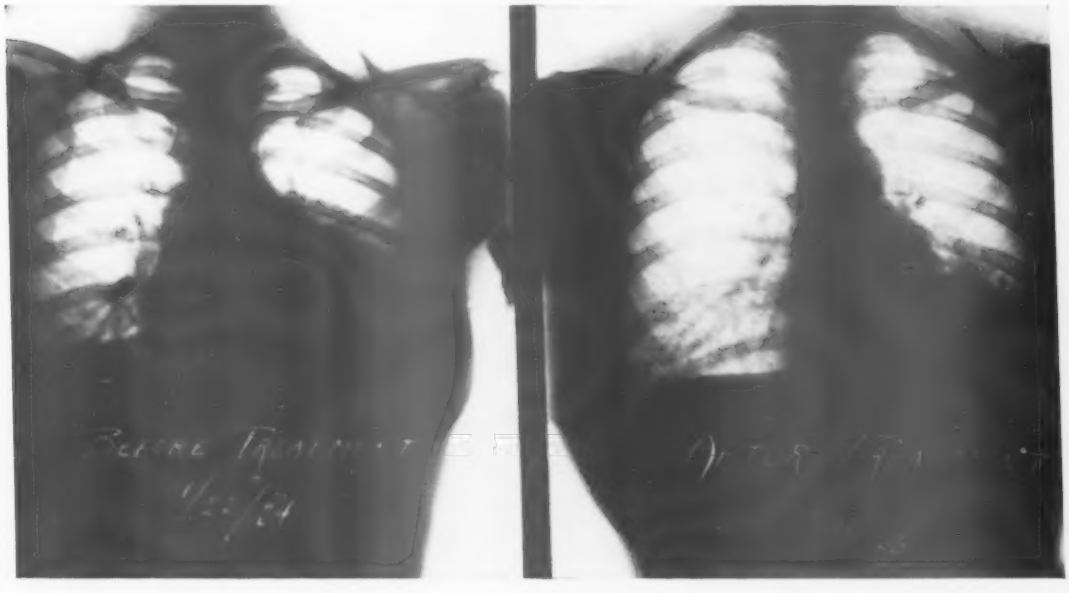

Fig. 11. Entire left lower half of chest involved. Outline somewhat irregular. Heart is displaced away from the lesion. Roentgenographically has the appearance of a chronic infection rather than new growth. Positive bronchoscopic biopsy. Nearly three years after treatment mass of density definitely smaller. Heart then displaced slightly to side of lesion. Patient had recurrence two years later. Is living and apparently well today except for continued bronchiectasis. Displacement of heart to right before treatment was due to the lung being filled with purulent exudate.

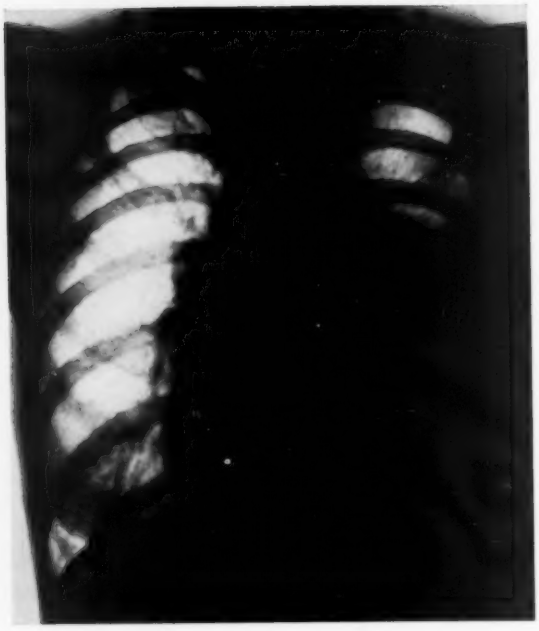

FIG. 12. Massive area of density. Rather irregular outline. Considerable displacement of the heart away from the lesion, due to serosanguineous fluid in the pleural cavity.

this problem in differentiation narrows down to relatively few cases. It must be remembered that many of these growths act just like foreign bodies. Farrell[2] observed one case in which he was able to demonstrate obstructive emphysema distal to the new growth. We all recognize the frequency of atelectasis so that the question of foreign body enters, but, since primary carcinoma occurs only in adult life, or practically so, the history is usually sufficient to rule out foreign body accident of recent occurrence. In one of Dr. Jackson's cases, malignancy developed in the walls of the chronic abscess cavity that was present because of a shawl pin that had been aspirated into the right lower lobe bronchus in infancy. The patient died as the result of hemorrhage from the carcinoma, at the age of thirty-seven.

Tuberculosis rarely enters the picture in our experience, with the exception of a very few patients in whom the lesion was of the infiltrating character involving upper lobe

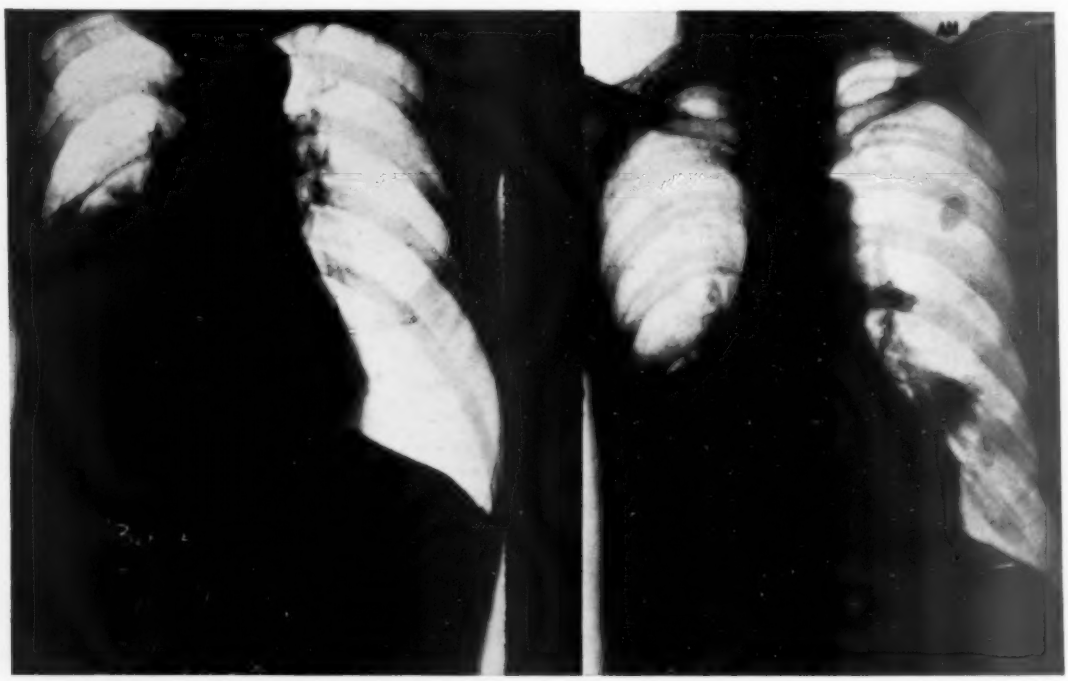

FIG. 13. Massive collapse, right lower and middle lobes. Displacement of the heart to the side of the lesion. The upper margin fairly sharply defined. Note reduction in size of mass as the result of roentgen treatment and at the same time evidence of metastasis developing in the left lung six months after first treated.

areas. In these cases there was hemoptysis but no tubercle bacilli in the sputum. There was absence of tubercle shadows in the roentgenograms. In such instances one would hardly be justified in making a positive diagnosis from roentgen study and history because the treatment for tuberculosis, on the one hand, and that for primary carcinoma, on the other hand, should certainly differ. The bronchoscopist, in such instances, even if he does not get a specimen of tissue for biopsy, obtains secretions through the aspirator that are very much more satisfactory for study than the sputum, and he has the advantage of those qualities of "fixity," "rigidity," and so forth, that Jackson[5] considers of definite diagnostic value. In most of our upper lobe cases, the lower margin of the lesion, and at times the upper margin, is so sharply defined as to make the diagnosis of tuberculosis very improbable.

A more definite difficulty lies in distinguishing between primary carcinoma that presents a sharply defined tumor mass in contact with the mediastinum and new growth that may arise from the mediastinum. Lesions, such as Hodgkin's disease or others of the lymphoblastoma type, tumors of the thyroid and thymus, and so forth, must at times be considered. Here, again, the element of displacement comes to be a definite and important factor. With mediastinal new growths or glandular enlargement, the trachea, aorta, and so forth, are usually displaced away from the lesion. Then, too, the blood picture and other physical evidences of glandular involvement are of help in a good many instances. Pressure on the bronchus from an enlarged gland or a tumor from the mediastinum may not be different from the external pressure of a carcinoma that has not intruded on the lumen of the bronchus. In such instances, fortunately, roentgen therapy is usually the treatment of choice. The lymphoblastoma type of lesion so often responds with great rapidity to radiation therapy that one can almost decide in a matter of days from the result of therapy whether the tumor is one or the other type of lesion.

Tumors springing from the chest wall in the extreme apices or even from other parts of the chest sometimes present differential problems, but careful attention to the appearance of the ribs will exclude those that spring from these structures, and, in the other instances, surgical biopsy is to be instituted when possible.

Metastatic malignancy of the lung, arising from primary carcinoma elsewhere, does not differ from some cases of primary carcinoma of the lung with metastases in other parts of the lung. Our group of cases, however, showed relatively few instances of pulmonary metastases.

We cannot in any way differentiate benign from malignant bronchial tumors. This is a problem that is left entirely to the bronchoscopist and the pathologist.*

* For discussion see page 873.

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THE THERAPEUTIC APPLICATION OF THE ROENTGEN RAY IN ANGINA PECTORIS*

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ROENTGEN therapy has occupied our attention equally as long as roentgenography, but in many respects our advances therein have been less important than in the diagnostic field. The therapeutic action of the rays has followed a more limited field, and, in a measure, justifiably so, because the rôle of radiation has occupied so important a place in the long effort to conquer our most dreaded manifestations of disease, the varying types of malignancy. Diagnostically, it would seem at times that consideration has been given to every possible application of roentgenography and yet we are constantly uncovering new, unthought of uses of this important medium of investigation, as well as perfecting older methods by advances in technique and improved apparatus. On the diagnostic side, results have been relatively concrete and definite. One problem after another has been attacked, solved at least temporarily to the best of our ability, absorbed into our diagnostic armamentarium, and attention has been turned to the next unknown, or perhaps another worker will take up the problem where one has left it and add some greater refinement with little or no discarding of the results obtained by the first. And so we have had a relatively unlimited field in our diagnostic work.

In treatment, to repeat, the big problem from the start has been that of malignancy and what a tremendous problem it has been and how discouraging, and how slowly have we progressed when we consider the labor expended, the attention given to technical development, the help we have received from all sides. There have been many bright spots therapeutically aside from the main problem, solved quite as satisfactorily and definitely as any diagnostic problem, but there has always been malignancy, and the hope of its eventual control by radiation to prevent us from investigating as fully and completely the possibilities of roentgen therapy as we might have otherwise. Perhaps, too, we have been, one might say, too honest and sincere in our research with this agent. It is the cure of malignancy we have sought and it is a cure which we accomplish in many of the cases where roentgen therapy is a proved success and we therefore may hesitate at times to employ that agent where we are fully aware that palliation is the best we can offer. Such an attitude might be justified in some cases but in such a field as we wish to consider, it is hardly fair to the patient.

Those who have undertaken any considerable amount of therapy are well aware of the incidental relief of pain experienced by many patients irradiated for malignancy. Frequently we meet with this effect as the first or perhaps the only effect of the treatment. We may overlook this fact but it is certainly one of the palliative effects which is uniform enough to console us, at least in part, for many of our failures in eventual cure. It is a result which has at times been forced upon us by our patients in their desperation in seeking any relief possible in their hopeless cases of malignancy. Frequently it has occurred that in an effort to convince them of the fact that we can promise no real hope of cure they will recall to us such and such a case in which at least the relief of pain was obtained. What the exact mechanism of this relief of pain may be has not as yet been determined definitely, whether a primary one on the nerves themselves or possibly secondarily through pressure relief. The fact remains that this palliative effect results from irradiation and it merits the widest possible investigation and experiment.

* Read at the Thirty-second Annual Meeting, American Roentgen Ray Society, Atlantic City, N. J., Sept. 22–25, 1931.

Our interest in this application of roentgen therapy was aroused in 1928 as the result of the successful use of radiation in the control of a case of undoubted true angina pectoris in a colleague. Following his initial attack which he survived after a considerable period of disability, he was naturally interested in finding any source of relief that future attacks might be avoided. Minor seizures had followed the original attack. At that time the attention of both himself and of us was attracted to an abstract of the successful results obtained in France with roentgen therapy. A desire was expressed that it be given a trial and the technique of the authors was followed as closely as possible. Complete relief was experienced, even from minor seizures, and has continued to the present time. Following this experience we made a determined effort to accumulate a series of cases that the method might be given a more thorough trial, but this was a slow process as might be expected. One is offering a comparatively new and untried remedy for a condition which demands the most certain and efficacious treatment at our command and we must anticipate trouble and prevent it rather than relieve it when present. We have no definite tests which aid us in determining the success of our treatment such as we may have when we bring about the disappearance of a tumor. Our most satisfying criteria of success have been the satisfaction of the patients and their physicians.

There is little need to recall the essential facts of the disease entity known as angina pectoris. We are all aware of its paroxysmal character, the sense of oppression or impending death, the location of the pain in the upper chest, with usually some radiation of the pain to the arms, all persisting for several minutes. All the cases in the series have conformed to this general clinical syndrome in varying degrees of severity, tending, however, to be of the more severe type and with rather frequent recurrences as it was usually by reason of the lack of complete success in the usual means of therapy that we were allowed to contribute to their treatment.

We do not wish to offer any theories as to the mechanism of the condition, its pathology or etiology. We have been impressed, as we believe are most of our clinicians, by the relatively greater frequency of this condition of late than in years previous. We find that there seem to be many more cases available for treatment, especially in the last year. The number in our series, 19, while not as large as we had hoped to be able to accumulate must be considered as rather favorable when it is remembered that we are located in a subtropical community and in the presence of a large negro population, and the relative rarity of angina in the tropics and in the negro race remains one of the curious features of the condition. All our cases have been patients past middle life and the proportion of male to female has been 15 to 4.

We do not pretend that the therapy of these patients has been confined exclusively to roentgen irradiation. There has been the usual employment of accepted measures for the relief of the attacks and the usual cautions have been extended to the patient in the way of efforts at avoiding future attacks by a proper regimen of life, with perhaps some additional aid from drugs. Practically all of our cases have come to us as a result of a failure of the prevention of the succeeding attacks by these measures, and in this sense it can be felt that radiation may be truly considered to have accomplished a part of the relief which has been rather uniform. Certainly none of our patients have required the resort either to surgery or injection.

The technique which we have employed differs at present both from that which we used originally and that which has been used by various other authors. Our first dosage was rather heavy, our attempt being to stay just within erythema limits. This was the method followed in our first three cases. Since then much smaller dosage at more frequent intervals has been used until we are at present using a more

or less standard technique with the following factors: kilovoltage, 140; milliamperage, 5; distance, 20 inches; filtration, 0.25 mm. copper plus 1 mm. aluminum; time, 8–10 minutes. This gives us on the average a dosage of approximately 150 r. The radiation is applied usually to the anterior chest wall, left side, occasionally similarly from the back. Our practice is to give such applications every two weeks until four exposures have been given or the patient's symptoms are entirely under control. After this, further treatments have usually been given at intervals of six weeks to two months. Our reasons for the more moderate dosage which we are using have been two, for the most part. One of our early patients where heavy dosage was used experienced a rather severe attack of roentgen sickness and in consequence was temporarily in an extremely critical condition. Furthermore, in the relief of pain following roentgen therapy which we have all noted at times without giving the matter any really serious thought, this has quite as frequently followed exposures of moderate intensity as in the heavier dosage. Certain of these angina patients seem to have as a part of the clinical syndrome an extreme nervousness and anxiety which renders long-continued exposure difficult and the success of the technique which we have adopted renders it within the tolerance of practically any patient and furthermore within the capacity of the majority of installations.

Our cases may possibly have been of the milder types of the disease. They may have been anginoid in character rather than true cases of angina pectoris. They have not been considered so by our clinicians and our success has been quite uniform. Of the 19 cases treated, one is dead of an intercurrent disease. The remaining 18, as well as their physicians, feel that the results have been satisfactory and both believe that the roentgen therapy has been the deciding factor in the control of their symptoms.

A review of the literature is not necessary here as there seems to be nothing of striking importance which was not covered in the article by Sussman[1] recently published on the subject.

Two of the more typical cases follow:

CASE I. Miss M. W., aged forty-four. Blood pressure, 240/110. Heart normal except A-2 accentuated. History of two anginal deaths in family—mother and brother. Anginal attacks began early in 1930. It was impossible for her to go out at this time because the least exertion would bring on definite, severe attacks. On February 5, 1930, we began roentgen therapy and following three such treatments, distinct relief was reported. These treatments were continued at intervals from 1930. As roentgen therapy progressed the patient could not only walk with comfort but was able to go downtown, and to attend to her ordinary business, that of vocal teacher. Towards the end she was able to go up a full flight of stairs without any discomfort. She was herself most enthusiastic as to the relief obtained from the therapy. This patient died April, 1931, of an acute dilatation of the heart.

CASE II. C. L., male, aged fifty-four. Patient complained of typical pain in chest, with some sense of oppression in the precordial region. The pain continued down the arm on the left side, these symptoms coming on following exertion. In September, 1930, we began roentgen therapy; it was not until the latter part of October, following three treatments, that there was any definite evidence of improvement. From this time on, patient had little discomfort and has been able to carry on his usual occupation of railroad supervisor. Treatments have continued up until the present time, with, however, no recurrence of the pain.

To summarize the effects of roentgen therapy in angina, we feel we can do no better than to quote the words of Dr. W. P. Bradburn, whom we have to thank for the majority of our cases: "Roentgen therapy has given definite relief to the patient. Although it is too early to make any statement as to the ultimate effect, I feel that the relief of pain, lessening of discomfort and restoration of patients to their ordinary way of life is a result entirely worth while."

[1] Sussman, M. L. Treatment of angina pectoris by paravertebral short wave radiation. AM. J. ROENTGENOL. & RAD. THERAPY, 1930, *24*, 163–168.

DISCUSSION ON PAPERS BY DRS. MANGES, AND SAMUEL AND BOWIE

Dr. George W. Holmes, Boston. I will discuss Dr. Manges' paper first. There is no question, I am sure, as to the correctness of his statement that the number of cases of primary carcinoma of the lung are increasing. As he suggests, whether that is due to better diagnostic methods or whether it is due to actual increase in the disease is not entirely settled.

Another point on which I would agree with him but would like to emphasize is the multiplicity of the forms of the lesion. It can simulate almost any disease of the lung. There is nothing characteristic of carcinoma.

I would like to stress one point that he did not mention, although I am sure he has it in mind, and that is the changes seen which are due to plugging of a bronchus. This seems to be a rather common finding and there is a definite change in the appearance of the chest which follows it.

I looked up the cases in our hospital some years ago and at that time I was able by going over all available records to find 16 cases. Recently I reviewed the past five years and during this rather short period the diagnosis of primary carcinoma of the lung was made 30 times. Out of this group, 9 received roentgen therapy; of the 9, all except 2 are dead, and those 2 are very recent cases. The average duration of illness was longer before they came to us than it was after we saw them, and that was about six months. The duration of life after their first visit to the hospital was about six months.

In reading over the records of the roentgen treatment, one could not help being depressed. I think our experience can be summed up in the statement, that irradiation did very little, if any, good.

Our cases were not well selected for radiation therapy. A case with a plugged bronchus, and suppuration, probably should not receive heavy radiation; such a procedure may tend to break down normal tissues and spread the disease.

I noticed in the cases which Dr. Manges showed, that the ones which did well did not show extensive collapse or involvement of the lung outside of the bronchus.

It is my feeling that a safe procedure in these cases would be moderate doses at first; later, after the infection clears up to some extent, heavier treatment could be given.

In the study of this group of cases, a record of the position and respiratory excursion of the diaphragm is important; roentgenoscopy is not always possible with these patients. We have worked out a technique which we find works very well for this purpose and which is also adaptable to the study of postoperative pulmonary complications.

I would like to show you a slide and give you that technique. The film from which this slide was taken was made with the portable apparatus and the technique consists of two exposures: one to show the diaphragm at inspiration, and one to show the diaphragm at expiration. The only trick about it is to make the exposure at inspiration very much shorter than the exposure at expiration. Between one-fourth and one-fifth of the total time should be given to the inspiratory phase and the remainder to the expiratory phase. It is of value to be able to record the position of the diaphragm. In some cases we found that the record on the film was more accurate than our roentgenoscopic observation. To record paradoxical motion Dr. Thomas, who has done most of the technical work, has developed a grid, a description of which will be published in this Journal.

In regard to angina pectoris, one of the earliest observations in the use of the x-rays in therapy was that pain could be relieved by it. You are all familiar with the relief of pain which follows irradiation in metastatic carcinoma. Of course you also know that the dose required to do this is often below that which would destroy the carcinoma. The relief from pain is altogether too prompt for it to be due to actual shrinking of the tumor. There must be some other process which has to do with the relief of pain. One of the theories that has been advanced is that it is due to a blocking of the pain sense in the sympathetic plexus, very similar to what the surgeon does when he injects alcohol into the stellate ganglia.

The treatment we gave was given on this basis. It was an attempt to block the pain since at the stellate ganglion the exposure was given posteriorly over the ganglion in suberythema doses. We tried to select patients who were intelligent enough to give us a fair account of their symptoms, because the results have to be based entirely upon subjective symptoms, and, as you all know, they are most unreliable.

We treated 17 cases; 10 showed definite improvement and 7 did not. In 4, the treatment was incomplete. In other words, a little over half showed a definite improvement.

Just before coming to this meeting, I asked one of the members of the Cardiac Clinic to review the data again and to bring it up to date. The follow-up is incomplete, but some of the patients seem to have had some permanent relief. The majority have had the treatment repeated.

So to sum up our results, a little over half of the patients showed definite improvement (relief from pain) and a fair percentage of these patients had permanent relief. Of course, one would not expect that life would be prolonged because the treatment is symptomatic and not curative.

DR. LOUIS H. CLERF, Philadelphia. I wish to express to you my appreciation for the privilege of discussing Dr. Manges' very interesting paper on bronchial carcinoma. Whether cancer is on the increase or not, we do know that the diagnosis of cancer of the lung can be made in the living, and it is not necessary to wait until metastasis appears or until an autopsy is done. Improved roentgen diagnosis and bronchoscopy are in great part responsible for this.

Dr. Manges stressed the question of cancer-consciousness. We hear that everywhere, and it is very, very important. That is one of the reasons why more cases are sent by the internist to the roentgenologist. He is becoming cancer-conscious, and that, of course, covers the question of teamwork which is also very important. Until we think of cancer and until we also believe in teamwork, many patients will slip through our fingers and the diagnosis will not be made until the disease is well advanced, a matter of little importance to the patient and of only didactic interest to us.

The variability of the roentgen findings in cancer corroborates the clinical and physical picture which is an extremely variable one. That tends to delay in diagnosis and this brings me to bronchoscopy in diagnosis. We know that new growths are more commonly found in the larger bronchi and that the larger bronchi permit of bronchoscopic exploration. Dr. Manges' cases were all proved cases by biopsy. We do not know how early some of them were; I do know that in one case the only symptom was a wheeze. The internist was cancer- and not asthma-conscious. He thought a bronchoscopy should be done, and we found a relatively small growth in the left lower lobe bronchus. That patient was treated by Dr. Manges and he is still alive and apparently well after two years.

We must do a bronchoscopy to rule out foreign body, broncholith, and other lesions. While foreign bodies are more common in the young, they do occur in adults. Broncholiths occur during the cancer age. At times cancer is confused with lung abscess or bronchiectasis. These may complicate the picture, but a diagnosis can be made by bronchoscopy.

The finding by bronchoscopy may be absolutely positive; a section of tissue may be removed for histologic examination. There can be no question about a positive histologic diagnosis. There are, however, cases where the growth is extrabronchial, although it unquestionably springs from one of the smaller bronchi, and, as it increases in size, produces compression of the larger bronchi. It is inadvisable to take a specimen through the bronchoscope in these cases, since one sees a relatively normal bronchial wall. In these cases, the bronchial wall is usually absolutely fixed and rigid. This can be considered as typical of bronchial cancer.

There are certain definite findings that the bronchoscopist can observe in these cases which will lead him to make a positive diagnosis of cancer, although he may not remove a specimen of tissue for the pathologist. That is why early bronchoscopy is so important in these cases and why it should always be employed if there is a question of diagnosis.

DR. B. R. KIRKLIN, Rochester, Minn. In view of the fact that the incidence of primary carcinoma of the lung has shown a marked increase in recent years, I think that Dr. Manges' excellent paper is very timely. Prior to 1925, comparatively few cases of primary carcinoma of the lung had been seen at the Mayo Clinic, but since May of that year 94 cases of primary carcinoma of the bronchus, proved by bronchoscopic examination and biopsy, have been encountered. Twenty-three of these have been seen since January 1, 1931. In addition to the 94 cases definitely proved by direct biopsy, probably an equal number have been observed in which the diagnosis was fairly sustained by the routine examination, biopsy of lymph nodes, or typical roentgenologic manifestations.

In the past, primary carcinoma of the lung has been considered hopeless, but of late, as Dr. Manges has pointed out, radium and the roentgen ray have given valuable therapeutic service. In our series of 71 cases covering the period from May, 1925, to January, 1931, ten patients are still living with an average survival for fifteen months. All of these were treated with radium or roentgen radiation or both. One pa-

tient is alive and apparently well after four years, and another after three and one-half years. Seventeen of these patients are still living, although 7 are failing rapidly. Only 2 of the 7 received radiotherapy; the 10 others were all treated with radium and the roentgen ray.

Within the past month I saw a very interesting case. The patient came to the Clinic with all the symptoms and objective evidence of a brain tumor. Roentgen examination of the chest disclosed a circumscribed dense area in the upper lobe of the right lung resembling a single metastatic lesion. Since metastatic growths are almost invariably multiple the question naturally arose as to whether this was a case of primary carcinoma of the lung with metastasis to the brain. The patient's condition was such that exploration of the brain was thought advisable. A specimen of tissue removed from the right frontal region of the brain for biopsy revealed adenocarcinoma of grade 4, with evidence of pulmonary origin. Similar cases are not uncommon.

I have also seen one or two cases with the typical roentgen picture of primary carcinoma of the bronchus which proved to have a metastatic lesion of the bronchus from a distant malignant tumor. To illustrate: One patient had definite roentgen evidence of a lesion in the right bronchus; bronchoscopic examination by Dr. Vinson followed by biopsy showed a new-growth typical of hypernephroma, and subsequently the hypernephroma was discovered.

Of the two types of primary malignancy to be considered, namely, parenchymal and bronchial, the latter is by far the more common. The shadow of a bronchial growth is usually centered at the hilum. However, as emphasized by Dr. Manges, the growth is often too small to cast a definite shadow or is concealed by the secondary manifestations; in such cases the localized atelectasis which is rather constantly present should direct the examiner's attention to the possibility of a primary bronchial carcinoma. Often in advanced cases the lung is obscured by effusion, and the roentgen examination should be repeated after paracentesis. I think the roentgenologist should always have primary carcinoma of the lung in mind when studying films of the chest, and I regard the roentgen signs of this disease as sufficient to warrant the diagnosis. However, if possible, tissue should be removed by way of the bronchoscope for confirmation.

Dr. Manges (closing). There were parts of my paper, of course, that I did not present because of lack of time. I included in the paper remarks on the differential diagnosis between mediastinal tumors of various kinds and this disease and also certain other things.

Replying to Dr. Holmes' discussion, I think he probably did not follow me closely or he would have noticed that I did say that atelectasis due to plugging of a bronchus or occlusion of a bronchus from these growths was perhaps our most dependable single sign. That is, there is atelectasis, there is retraction of the mediastinal structures to the side of the lesion because of the atelectasis distant to the bronchial structure.

In the first place, I intended to say something about therapy. When I got into the paper, I found it was impossible to cover what I wanted to do from the diagnostic point of view and also take up the question of treatment. Briefly, though, it has been my custom to give these patients a little less than the intensive dose that we use, for instance, in other parts of the body, since I believe the lung tissue permits the passage of more radiation than the soft tissues in other parts of the body. I think if we apply the same dose over the thorax that we do over the lower abdomen at a given point in the depth of the lung tissue, we will get a greater irradiation effect than we do elsewhere. So we take that into consideration and allow from 10 to 15 per cent difference in the amount of radiation that we deliver at a point in the depth.

When the lesion is localized, we try to localize our radiation effect as much as possible. When the lesions occupy or involve large portions of the lung field, of course we treat the entire area involved, very much on the same principle that we treat malignancy elsewhere. That is, we aim to give a full dose. We use Dr. Pfahler's saturation method, as a rule, although in a few of our best results we did not do that.

Dr. Kirklin brings up the question of making diagnosis from the roentgen appearance alone. I hope that we all will be able to be more confident of our opinions in this particular disease than we have been in the past, but I would hesitate very much to make positive diagnosis from roentgen findings alone if the lesion was at all available to bronchoscopy. He showed one case in which the patient improved but the lesion did not disappear. I have one living eight years that had all of the clinical symptoms of primary carcinoma. We did not obtain tissue

for biopsy. He was treated with roentgen radiation. He is a member of the Philadelphia Fire Department. I treated him first in 1923, and within the last few months, the Department of Safety has sent me roentgenograms of his chest, and the lesion is approximately one-half the size it was at first, but the shape of it and the location of it and everything else is practically as it was before I started to treat him. He hasn't been bleeding. He doesn't cough much. He has a little congestion in his upper veins, but not so much.

Tuberculous Meningitis Cured by Deep X Ray Therapy.—From time to time cases of tuberculous meningitis with recovery have been reported, but the total number is small and no satisfactory conclusions about the treatment of this terrible affection have hitherto been possible. Prof. Z. von Bókay,[1] of Debreczen in Hungary, now modestly reports success in five proved cases treated with deep X rays between May and August, 1931. It must be the first time that any one person has seen this number of recoveries and the results demand close scrutiny. The ages of the five patients were 12, 6, 4½, 3, and 3 years and the diagnoses were confirmed either by the finding of tubercle bacilli in the cerebro-spinal fluid or by the positive result of inoculating of the fluid into a guinea-pig. In one case, where bacilli had not been found in the fluid, recovery was so rapid after radiotherapy that the diagnosis of meningism was made, but five weeks later the post-mortem examination of an inoculated guinea-pig showed that the cerebro-spinal fluid had been tuberculous. The irradiation employed is described as follows: 162 kilovolts, 4 milliamperes with 0.25 of zinc and up to 3 mm. of aluminium filter, 150–200 R. units with a focal distance of 34 cm. This was applied to the base of the neck, forehead, and temporal regions, the exact situation irradiated varying slightly. Three to four applications were made in each case, with one to two days between the first two, and three to four days between subsequent applications. Recovery, where it took place, seems always to have been complete, a noteworthy feature being the rapid gain in weight as the meningitic symptoms disappeared. Loss of hair appeared to be the only deleterious result of the irradiation and it is possible that the alopecia produced may be permanent, although in one case hair was beginning to grow again over the bald areas a few days after the child left the hospital. A more serious possibility is the subsequent development of hydrocephalus or mental deficiency, and it is too soon to say whether Bókay's patients will escape these sequelae. Moreover, during the months in which these five cases were treated successfully there were twelve similar cases in the hospital in which X rays failed completely. Discussing the question of what factors make for success Bókay emphasises the fact that from a pathological point of view, tuberculosis may be present either as a diffuse exudative process affecting all the meninges or as a local collection of tuberculous material in some portion of the meninges. The latter condition is closely allied to the 'leaking tuberculoma' seen in older children and adults who have survived the presence of tubercle bacilli in the cerebro-spinal fluid; and many of the reported 'cures' of tuberculous meningitis have been thought to come into this class. It is impossible to decide the exact pathological lesion in Bokay's cases, but the clinical details given in his paper leave little doubt that they were genuine examples of tuberculous meningitis. This, of course, is often part of a generalised miliary process throughout the body and, where this is so, cure within the skull cannot be expected to save the child. Nevertheless, whatever the pathological condition, the cause of death is an increasing intracranial pressure and Bókay's point is that if this can be arrested a step forward has been made. The dosage of X rays employed is very big, but in such a condition as tuberculous meningitis he holds that the *non nocere* principle can be justifiably abandoned and that intensive irradiation of the brain should be carried out without delay.—*Lancet*, April 23, 1932, *1*, 894–895.

[1] *Jahrb. f. Kinderh.*, 1932, *135*, 69.

VOL. XXVII, No. 6

AN EVALUATION OF HIGH VOLTAGE ROENTGEN RAYS IN THE THERAPY OF CARCINOMA OF THE CERVIX*

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TO ESTIMATE the comparative value of various methods of treatment is difficult in any disease, and particularly so with carcinoma. Carcinoma of the cervix is especially inconsistent in its rate of growth, susceptibility to infection, invasive propensities and time of metastasis. While the age of the patient and the histologic type of the growth, to a certain degree, suggest the rapidity with which it may be expected to extend, up to the present time no uniformly dependable means of judging these variables is available.

From the standpoint of grading the degree of involvement, personal impressions may be at such wide variance as to completely change the statistical findings. The great discrepancies noted in the reports from different clinics employing similar techniques must, to some extent, imply divergent opinions as to precisely where one grade ends and the next grade begins. Clinics operated under a continuous personnel should produce good statistics for the evaluation of different modes of treatment.

The gynecologists to the Radiologic Service of the Philadelphia General Hospital, since the inception of the department in 1922, were both trained by Dr. John G. Clark, who was a pioneer in the use of radium for the treatment of cervical carcinoma. Likewise, the therapy has been administered continuously under the supervision and advice of our physicist, J. L. Weatherwax, and while radical changes were made in our technique in 1928, there has been no deviation in the standardization of our apparatus or in the calculation of the doses delivered. All examinations before treatment as well as at "follow-up" visits were made by the gynecologists, who also made most of the local applications until recently, when much of this work was given over to the resident radiologists. Each treatment is now planned routinely by consultation between representatives of these two specialties. Cases presenting uncommon features also require the advice of our physicist.

Previous to 1928, malignancy of the cervix was treated in the conventional manner: namely, approximately the equivalent of 2,400 millicurie-hours of radon in a cervical "T" tube with filtration of 1.0 mm. brass, 0.5 mm. silver, and 2 mm. rubber was applied to the growth. High voltage roentgen rays were used at first rarely, very cautiously, and only for the most hopeless types of patients. Toward the latter part of this period we began to realize that in the far-advanced cases high voltage roentgen rays, alone or combined with radium packs, caused less damage than did the more caustic radiation from the thinly filtered radon against the lesion. Consequently, the former form of therapy was, for the most part, restricted to patients whose condition made the use of radon with light filtration dangerous. Since the middle of 1928, except in patients whose general condition prohibited any sort of irradiation and those who refused to submit to treatment, high voltage roentgen rays have been employed practically routinely, regardless of the extent of the disease. In the far-advanced cases this was the only form of treatment given. Many of these patients improved sufficiently to make local irradiation possible at a later date. Where the growth was less advanced the standard treatment consisted of application of radon in the uterine canal and the vaginal exposure of the growth, and

* From the Gynecologic Division, Department of Radiology, Philadelphia General Hospital, Philadelphia. Read at the Thirty-second Annual Meeting, American Roentgen Ray Society, Atlantic City, N. J., Sept. 22–25, 1931.

exposure of the pelvis and spine to short wave length roentgen rays. In the intrauterine application, the filtration employed was 1.0 mm. brass, 0.5 mm. Ag, and rubber. The dosage ranged between 2,000 and 3,000 millicurie-hours, depending upon the depth of the uterine cavity. The tubes of the element were inserted in tandem, approximately one tube per inch depth of the uterine canal. The vaginal portion of the growth was usually exposed to gamma radon radiation, the dosage being about 3,000 mc-hr., with filtration of 3 mm. lead, 0.5 mm. Ag, and rubber, at a distance of 1 cm. These tampons were applied transversely against the neoplasm, and horizontally into each vaginal fornix, whenever anatomic considerations permitted. Each position was treated with $\frac{1}{3}$ of the total dosage. The tampons were inserted one at a sitting, and were retained by gauze packing which also protected the structures that were not to be irradiated.

The high voltage roentgen treatment since July, 1928, has been administered in accordance with the four-field adaptation of Pfahler's saturation technique as developed by Weatherwax,[1] and Weatherwax and Widmann.[2]

Gamma radium packs were used in a small number of cases here. These were constructed with fixed lead capsules 3 mm. thick, soldered to plates of 0.25 mm. of copper. The radon in glass was fixed in silver tubes of 0.5 mm. thickness and these tubes placed in the lead capsules. The capsules were arranged upon the copper plate in two rows of six each, 2 cm. apart. This gave an irradiated area of approximately 10×15 cm. A uniform distance from the skin was secured by interposing a layer of felt 4 cm. in thickness. The average dosage administered through the four fields was approximately 40,000 to 50,000 mc-hr.

The following report is based upon the duration of life of 437 women who were examined in our clinic and were followed until death. These patients were grouped according to the classification of the American College of Surgeons, into Stages 1, 2, 3, and 4. In Stage 5 we included all cases who had received treatment, either surgical or radiological, in other clinics. The cases in each group were further subdivided into: (1) those receiving no treatment at all; (2) radon directly to the growth, with filtration of 1.0 mm. brass, 0.5 mm. Ag, and 2 mm. rubber; (3) radon as above, with the addition of radiation in the form of high voltage roentgen rays, heavily filtered radon tampons or radium packs, separately or combined; (4) high voltage roentgen rays alone, and (5) high voltage roentgen rays and gamma radium packs in various combinations. Since some of these methods were used for a comparatively small number of patients, it was considered unnecessary to make further subdivisions.

The clinical material available for this study was to a great degree of the type generally regarded as hopeless. The Philadelphia General Hospital, being the free municipal hospital of the city, in addition to receiving a large proportion of its patients from the pauper class, is the "dumping ground" of undesirable patients from all of the other hospitals. The Radiologic Department is no exception in this respect and in consequence our admissions are, in a large measure, patients who are referred to us by institutions or physicians because they are believed to be beyond the possibility of a cure, and for whom care must be provided during the short time which remains for them to live. As a result, we rarely have the privilege of treating cases in which there is a fair opportunity of effecting a cure, yet by the same circumstance we are provided with an abundance of material with which to attempt palliative measures and which we can observe until the termination of the cases. Consequently, we have acquired an interest in the palliative as well as the curative powers of treatment for carcinoma of the cervix.

[1] Weatherwax, J. L. Physics of Radiology. Paul B. Hoeber, Inc., New York, 1931.

[2] Weatherwax, J. L., and Widmann, B. P. Physical factors in radiation therapy and their clinical application. *Radiology*, 1929, *12*, 297–308.

In this review, no living patients have been considered, thereby eliminating all but one of our Stage 1, and 3 of our Stage 2 cases. Many of our Stage 3, 4, and 5 patients are still living and will be reported separately at a later time. Our only Stage 1 growth in this series was a squamous cell carcinoma, given lightly filtered radon, locally, and high voltage roentgen therapy to the pelvis. This patient lived for twenty-one months after treatment. The lesions rhage and one from cardiac failure. Thirty-one who received radon (1.0 mm. brass, 0.5 mm. Ag) enjoyed an average duration of life of 7.6 months after treatment. Three lived less than one week, and one lived for two years. For the 63 who received, in addition to lightly filtered radon to the neoplasm, high voltage roentgen rays or some form of hard gamma radiation, the average time lived after treatment was 11.8 months. One died forty-seven months

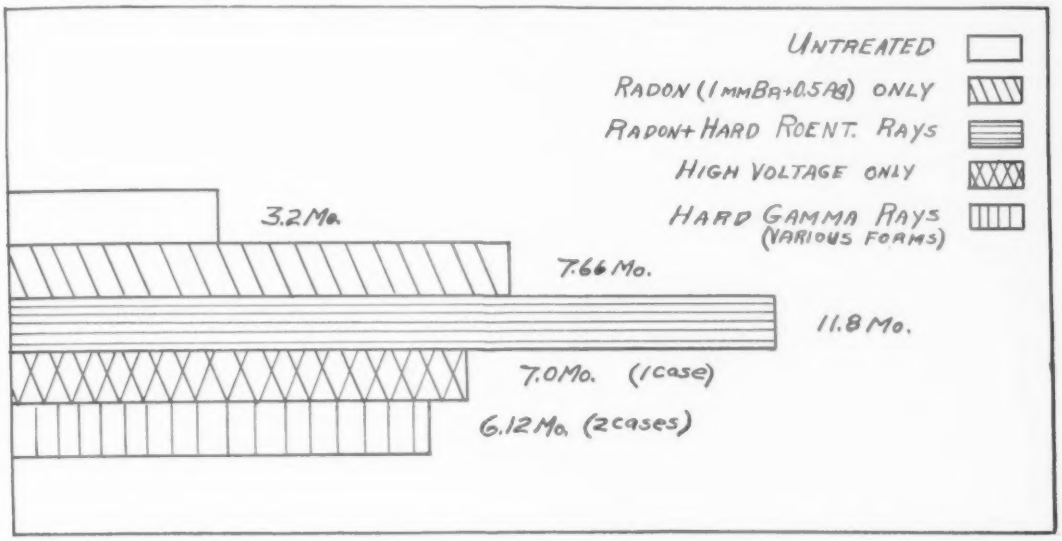

FIG. 1. Stage 3.

falling into Stage 2 were 3 in number. The first, a squamous cell carcinoma was treated with lightly filtered radon to the growth and deep roentgen rays to the pelvis, and lived for nineteen months. The second patient, also having a squamous cell carcinoma, received lightly filtered radon to the growth and radon packs to the pelvis, and lived for twelve months. The third lesion in Stage 2 was an adenocarcinoma which, in addition to receiving lightly filtered radon, was exposed to both high voltage roentgen rays and radon packs. This individual remained alive for only ten months.

There were 96 cases in Stage 3. Eight of these received no treatment at all. Of these, 5 refused treatment, and 3 died before therapy was instituted, 2 from hemor- later, and 7 lived for more than two years. The only patient who was treated with high voltage roentgen rays alone lived for seven months. Fourteen of this group received radon locally and gamma radon packs. In this group, the average duration of life after treatment was 11.3 months. Two cases whose therapy consisted of packs in the one instance, and tampons plus high voltage roentgen rays in the other, lived five weeks and eleven months, respectively.

From this tabulation it would appear that local treatment of the carcinoma is more efficient than therapy with short rays from a remote focus. The best results in Stage 3 cases, however, were obtained by a combination of local treatment plus short wave length radiation in the form of high voltage roentgen rays and packs.

TABLE I

Stage 4 1922–July, 1928	
Total treated	32
Treated radon (2 mm. brass, 0.5 mm. Ag)	20
Packs alone	1
High voltage alone	11
Untreated	85
July, 1928–1930 inc.	
Total treated	41
Untreated	22
(Untreated living over 15 days)	4

Before analyzing the results obtained with the Stage 4 cases, we should consider therapeutic policies which were practised until death. Between these dates, only 32, or 28 per cent, of the patients were treated, one received only radon packs and 20 had only lightly filtered radon applied to the growth. The cases treated with high voltage roentgen rays and packs were the type in which radon directly to the lesion could not be used. After July, 1928, the four-field technique was gradually instituted, and from that date until the end of 1930, out of a total of 63 Stage 4 cases admitted, 41, or 67 per cent, received treatment. Thirty-four of these were given only short

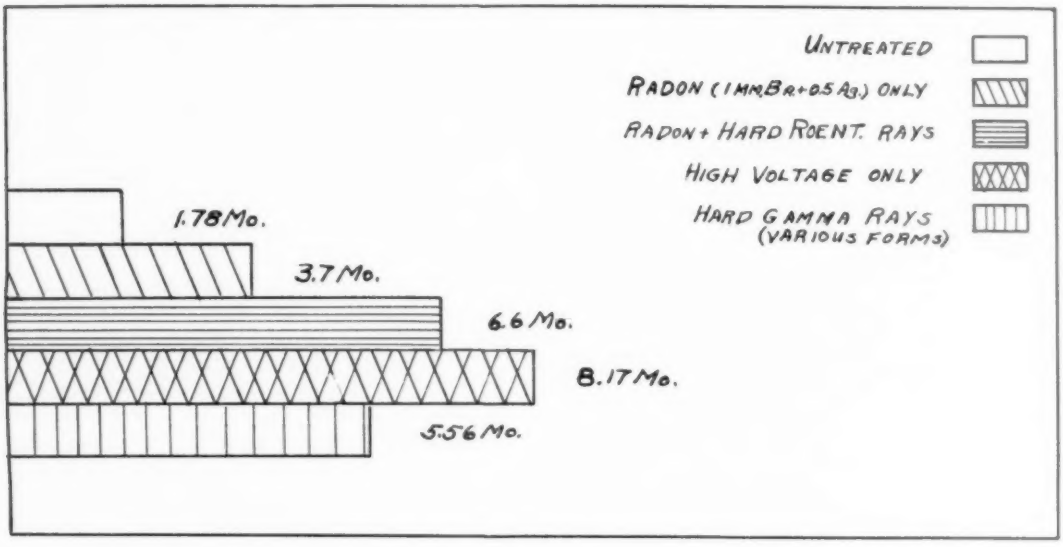

FIG. 2. Stage 4.

during two periods covered by these statistics. From 1922 to July, 1928, one hundred and seventeen patients in Stage 4 were examined. During this time radon (1.0 mm. brass, 0.5 mm. Ag), applied directly to the tumor was the routine treatment in our clinic for all cases. High voltage therapy was employed eleven times for patients who were beyond the point where local treatment could be employed with safety. In these instances the therapy was used with greatest caution and in the light of our present knowledge was consistently inadequate. For the most part patients too far advanced for local treatment received no radiation therapy at all but were made as comfortable as possible in the wards

wave length irradiations from a remote focus. It is therefore apparent that the individuals treated with deep therapy were, on the whole, the poorer prospects for palliation, a point which should be borne in mind in reviewing the results obtained in these 180 Stage 4 patients.

The average duration of life after admission for those untreated was 1.78 months. Local application of radon (1.0 mm. brass, 0.5 mm. Ag) increased this span to an average of 3.7 months. One woman lived only three days after being treated, and 5 did not survive the second week. The longest clinic life in this group was eleven months. The average life duration after treatment with radon (1.0 mm. brass, 0.5 mm. Ag)

combined with short wave length roentgen rays was 6.6 months, and with high voltage alone 8.17 months. Four in this last class who failed to survive longer than the first month were in such poor physical condition that their full course of treatment could not be completed. Of those receiving their entire treatment, one lived for twenty-eight months and 2 remained alive for twenty-three months. Many of these women were rendered well temporarily and were able to resume lives of usefulness and comfort for varying periods of time.

TABLE II

Stage 5 1922–July, 1928	
Total treated	59
Treated radon (2 mm. brass, 0.5 mm. Ag) alone	24
Packs alone	6
High voltage alone	29
Untreated	64
July, 1928–1930 inc.	
Total treated	33
Untreated	2
(Untreated living over 15 days)	0

One hundred and fifty-eight of our cases had been treated in other clinics before being received by us. Many of them were referred not for the purpose of obtaining treatment but in order to provide them with sustenance and nursing for the remainder of their lives. During the period from 1922 to July, 1928, only 56 per cent were treated, but from July, 1928, to 1930, inclusive, all but 2 of 35 patients admitted to the clinic received treatment. Neither of these untreated patients survived the fifteenth day. As a group the best results were obtained after local treatment with radon (1.0 mm. brass, 0.5 mm. Ag), plus high voltage roentgen rays. The results, however, were as variable in relation to the therapy administered as were the lesions when first seen by us.

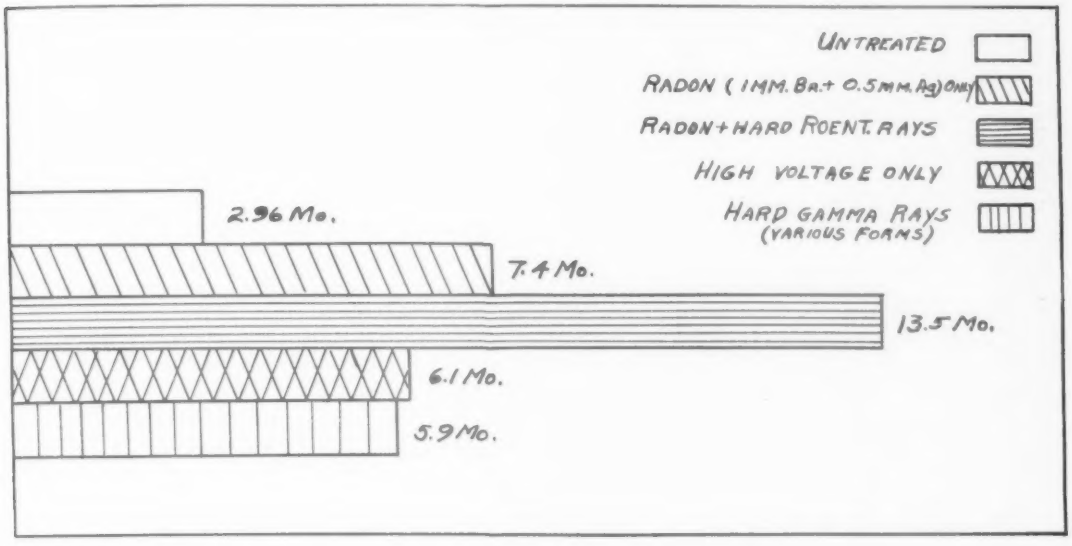

FIG. 3. Stage 5.

The Stage 4 group are for us the most enlightening, because they illustrate so clearly the striking advantage of high voltage therapy in effecting palliation in late cancers of the cervix. Not only is this type of treatment more efficient in delaying the extension of the disease, but the danger of lighting up an acute peritoneal infection or a fatal septicemia, as we hope to prove in a subsequent report, is almost negligible, whereas with local treatment, such unpleasant experiences are by no means uncommon. Furthermore, high voltage roentgen rays carry with them none of the dangers of fistula formation, so frequently seen when lightly filtered radon is placed against the late lesion.

Two cases from the group treated with deep therapy only may merit special mention. The first patient admitted with a large vesicovaginal fistula, having been symptom-free and without any evidence of carcinoma for twenty-three months after treatment, was operated upon in an attempt to repair the fistula. This operation was followed in a few days by uremia and early death. In the other instance, a surgeon, eight months after our treatment, finding the patient free from any evidence of carcinoma, attempted a panhysterectomy, following which death ensued. These are mentioned only to deplore the use of surgery after brilliant irradiation results have been obtained in apparently hopeless cases.

The average time after treatment during which our late cases, treated with only high voltage roentgen rays were free from bleeding and pain, was 4.2 months. One woman, admitted with a vesicovaginal fistula, and treated with 1,167 ma-min., high voltage roentgen rays, gained weight for four months. The lesion remained healed and the uterus regained considerable mobility. While there was a recurrent ulcer at the end of six months, pain was absent until the eleventh month. Death occurred twelve and a half months after treatment. A second patient with a far-advanced lesion treated with deep roentgen rays alone, lived symptom-free for thirty months, then had a return of moderate pain, chiefly in the back and died at the thirty-seventh month. The third case which I wish to accord special mention was transferred from the Gynecologic Service of the University Hospital at my suggestion as I considered the patient beyond the possibility of treatment. We had treated this patient with radium locally on two separate occasions. On her third admission, following a severe hemorrhage, we noted complete destruction of the cervix and lower portion of the uterus, and a rectovaginal fistula. High voltage roentgen rays were given this patient, with the astonishing result that the huge crater healed, there was a gain of 42 pounds in weight, and complete disappearance of symptoms. This woman returned to her husband and children, apparently well for eleven months. At this time a small recurrence in the vault of the vagina was exposed to local irradiation in the form of tampons. Within six weeks the scar tissue which had replaced the old crater had disappeared and the patient died following a series of hemorrhages.

In this clinic, gynecologic experience over a period of nearly ten years has led to an enthusiastic appreciation of the great advance made in the therapy of carcinoma of the cervix by the introduction of short wave length irradiations. The marked improvement in the morale of the patients in our charge since 1928, when the regular and consistent use of deep roentgen therapy in adequate dosage was taken up, is a feature which cannot be shown statistically. Except for patients who are practically moribund on admission, high voltage roentgen therapy affords at least a short period of improvement, with its accompanying return of hope, to nearly everyone. Some can be returned as useful members of society for substantial periods of time. A number of these patients died without a return of symptoms. When pain did return it was usually a dull heavy discomfort in the back or lower abdomen, and rarely required large doses of opiates. Wards, instead of being occupied by pathetic, moaning creatures, have become a home for impoverished sick women, few of whom suffer greatly even up to the time of death.

SUMMARY

1. High voltage roentgen therapy is a distinct addition to the present therapeutic armamentarium for the treatment of carcinoma of the cervix.

2. Used in addition to local radon applications in Stage 3 and earlier cases, it will increase the expectancy of life.

3. Local irradiation of the growth should be practised in all cases earlier than Stage 4.

4. The therapy of patients, whose le-

sions have advanced to Stage 4, should be confined to external short wave length radiations in the form of high voltage roentgen rays or packs.

5. In late cases this treatment prolongs life, reduces pain, and restores hope.

6. Recurrent cases must be individualized and the plan of treatment should depend on the degree of extension of the growth and the general condition of each particular patient.

DISCUSSION

Dr. Henry K. Pancoast, Philadelphia. I do not recall at any previous time any paper read before this Society covering 437 dead patients and not including any living ones, but such statistics are often of considerable value, and especially in this instance by enabling one to compare untreated cases with those which are treated by different methods. This presentation shows especially the value of the use of deep or high voltage roentgen therapy in the treatment of these practically hopeless cases. In every class, at least in Stages 3, 4, and 5, when the deep roentgen therapy was used with or without the use of radium locally, there was a prolongation of life to about four times that of patients who received no treatment at all. We know that in most of the cases in these three groups, the local radium treatment would have had very little effect because the treatment was directed particularly toward lesions which were well beyond the reach of radium used locally. Of course, I do not refer to use of radium in packs on the surface. In a number of cases, it was evident that local radium was indicated because of certain lesions or nodules, either recurrent or advanced, which could be well treated by the localized use of radium. I believe that in most of the cases treated in these three groups who received radium internally, the radium was used with rather low filtration.

It is during the past two years that radium has been applied internally with very high lead filtration and it is too soon, of course, to find out just how much longer these patients might live. I think Dr. Behney told me the other day there had been an insufficient number of them that died to include in the statistics, but he could not include this group as some individuals were still living. It will probably be evident later on that there has been a further advantage in the use of highly filtered radium locally, in addition to the deep roentgen therapy. Such presentations as this can leave no doubt in the minds of gynecologists who have not favored deep roentgen therapy in these cases that it has a very distinct advantage. We treat cases with deep therapy and they die. I suppose we have not realized, even though they have died, that we prolonged their lives a considerable period over what they would have lived had they not been treated at all.

Dr. Behney (closing). The use of radon in late cases during the last two years was confined entirely to irradiation from a distance in the form of packs, except in a few instances in which tampons consisting of radon applied with a filtration of 0.5 mm. silver, 3 mm. lead, at a distance of 1 cm. and, of course, encased in rubber, were applied vaginally.

The conversation to which Dr. Pancoast referred with regard to early cases, was that we have had an insufficient number of very early cases to justify the construction of charts. We have had very few early cases. One Stage 1 growth in this series which was a squamous cell carcinoma treated with lightly filtered radon locally and high voltage roentgen rays to the pelvis, lived only twenty-one months after treatment.

Of three Stage 2 cases, the first, a squamous cell carcinoma, was treated and lived for nineteen months. The second patient, also a squamous cell carcinoma, received lightly filtered radon to the growth and radon packs to the pelvis and lived twelve months. The third lesion in Stage 2 was an adenocarcinoma which in addition to receiving lightly filtered radon was exposed to high voltage roentgen rays and radon packs. This individual remained alive only ten months. The remainder of our Stage 1 and Stage 2 growths, of which there are very few, are still alive.

INTERNATIONAL COMPARISON OF ROENTGEN-RAY UNITS*†

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WASHINGTON, D. C.

IN THE three years since the Second International Congress of Radiology, Stockholm, considerable progress has been made in the methods and technique for determining the "international roentgen" (r) —the unit used for roentgen-ray dosage. Of the three countries having national standardizing laboratories, Germany has adopted a large cylindrical air chamber, England has constructed a parallel plate ionization chamber, and the United States has abandoned its large parallel plate chamber in favor of the smaller chamber having a controlled electric field. France, while not yet having a central laboratory, has its roentgen-ray standardization well organized by Dr. I. Solomon, who is the official custodian of the French standard.

In view of these differences in apparatus and the fact that the international roentgen was of a somewhat provisional character, it seemed of utmost importance to compare the units as realized by the instruments and to determine the differences. It should be emphasized that the standard roentgen-ray ionization chambers devised in the three national laboratories produce a basic measurement of a physical quantity without any arbitrary specifications whatever. In France, the Solomon (R) unit has been in general use.

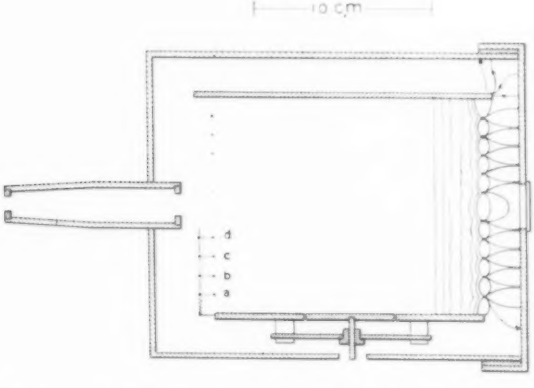

FIG. 1. Cross section of guarded field ionization chamber showing probable field at chamber ends.

The first international comparison of units was made in 1927 by Behnken who, with a calibrated thimble chamber, found differences between countries of ±4 per cent. This method had the disadvantage of involving roentgen-ray quality measurements of uncertain character. In addition, it has been found difficult to calibrate a thimble chamber with sufficient accuracy for such purposes.

Investigations at the Bureau of Standards led to the conclusion that the only completely satisfactory way to compare the units would be to make a direct comparison between the standards themselves. Of the three standard air chambers, that of the Bureau of Standards is the only one sufficiently small and portable to permit of ready transportation and easy setting-up in other laboratories. Hence, we transported to London, Berlin and Paris, the working standard of the United States and compared it directly with the other national standards.

The Bureau of Standards chamber has been adequately described elsewhere so that its characteristics need be reviewed but briefly. Figure 1 shows a cross section. It will be noticed that for a distance between the high potential plate and the collector plate of 12 cm., the guard plates are only about 1/4 the width commonly stipulated as necessary to insure a uniform field under ordinary conditions. This field correction is effected, however, by a series of fine aluminum guard wires, *a*, *b*, *c*— across the ends of the chamber having successively potentials in equal steps between

* Publication Approved by the Director of the Bureau of Standards of the U. S. Department of Commerce.
† Read at the Thirty-second Annual Meeting, American Roentgen Ray Society, Atlantic City, N. J., Sept. 22–25, 1931.

the plates—from zero to the saturation voltage (2,000 volts in this case). This is accomplished simply by making the guard wires part of a high potential dividing resistance connecting the two plates. The guard wire system also permits a smaller surrounding case to be used and thus reduces the distance between the diaphragm and collecting electrode. This minimizes the air absorption correction which is extremely important at the lower voltages.

Figure 2 shows a photograph of the assembled electrode system. The potential dividing resistances are mounted on the top and the whole system is placed in a lead box, *B*, about 18 cm. on each side.

The ionization current is measured by means of a null electrostatic system shown by *C* in Figure 3. The current from the ionization chamber is conducted to the compensator by means of a shielded rubber cable. By means of a new method, it is possible to calibrate this compensator with very high accuracy either in the laboratory or the field. A check of this calibration in Teddington, Berlin, and Paris showed a constancy to at least 0.1 per cent. The completely assembled roentgen-ray standardization equipment, for portable use, is shown in Figure 3, mounted on adjustable tripods to permit ready and accurate alignment in the other laboratories.

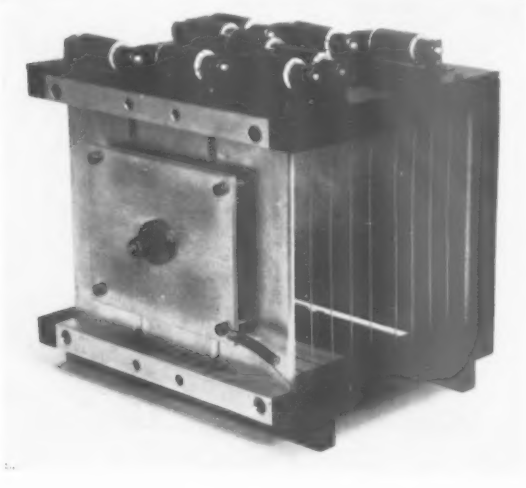

Fig. 2. Assembled electrode system.

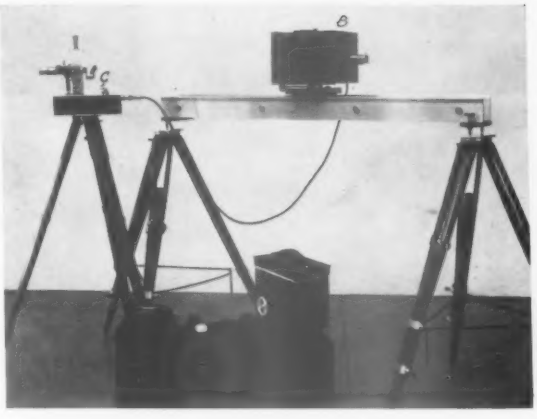

Fig. 3. Complete portable roentgen standardization equipment. *B*. Standard chamber. *C*. Electrostatic compensator.

In Teddington and Berlin, the replacement method of observation was used, with the entrant diaphragm placed at the same position with respect to the tube. Readings were made with the two chambers alternately inserted in the beam. The roentgen-ray output was controlled as carefully as possible at Teddington by high tension current and voltage meters; and at the Physikalisch-technische Reichsanstalt by keeping a thimble chamber in the beam during all observations.

Since the chambers involved differed in length, it was necessary to apply corrections for air absorption inequalities. Some of these corrections can be accurately made from available data, while others must of necessity be by interpolation and thereby subject to an error of perhaps 0.5 per cent.

An early comparison between the smaller guarded field standard and the larger Bureau of Standards air chamber showed an average agreement better than 0.1 per cent. A comparison of current measuring equipment with that at the Memorial Hospital, New York, the only other place in the United States having the null compensating system, showed an average difference over a wide range of currents of only −0.12 per cent. Since their chamber is essentially the same as the larger Bureau of Standards chamber, this indicates a

close agreement between the units of these two laboratories.

At the National Physical Laboratory of England, the bench for supporting their ionization chamber (*B*, Fig. 4) was so built that our chamber, *A*, could be placed directly on their bench, *D*, and very easily aligned. For protecting the operator, the current measuring system, *C*, was mounted on a tripod some distance away. Measurements of the intensity distribution showed that their roentgen-ray beam was very narrow, which called for extremely careful alignment of the ionization chambers. It was also found difficult to control their roentgen output very closely so that the precision of a simple observation was only about ±1 per cent, thus necessitating a large number of observations.

A careful study of their diaphragm system revealed a divergence of nearly 6 per cent from the Bureau of Standards system; consequently, the final close agreement between standards was obtained by making diaphragm corrections or by using the Bureau of Standards diaphragms on both chambers. By direct comparison, a difference of 1.5 per cent between the two current measuring systems was found and this was likewise taken into consideration in the final results. Their original system differed from that of the Bureau of Standards by about 7.5 per cent.

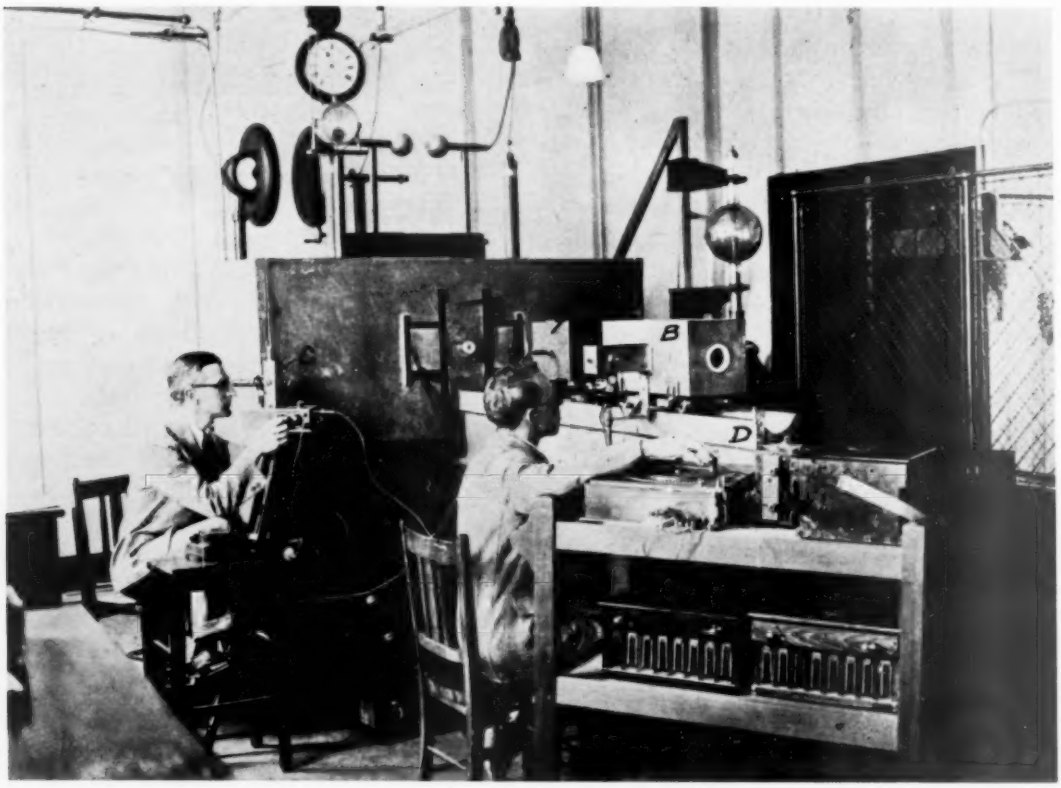

FIG. 4. Comparison of standards in Teddington (in actual use only one chamber on track *D* at a time). *A*. Bureau of Standards chamber. *B*. National Physical Laboratory chamber. *C*. Bureau of Standards compensator.

At the Physikalisch-technische Reichsanstalt, both the German and the Bureau of Standards chambers were mounted on optical benches placed at right angles to the beam, and the two brought alternately into the beam by sliding on their respective tracks (Fig. 5). Control of their high ten-

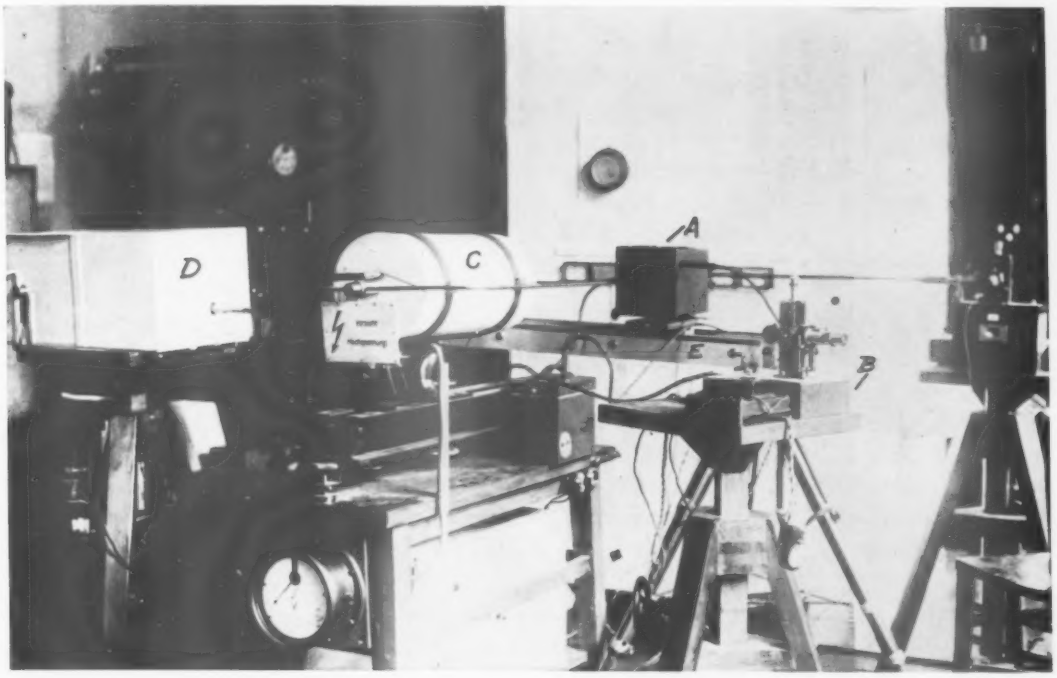

FIG. 5. Comparison of standards at Berlin. *A*. Bureau of Standards chamber. *B*. Bureau of Standards compensator. *C*. Physikalisch-technische Reichsanstalt chamber. *D*. Physikalisch-technische Reichsanstalt compensator. *E*. Bureau of Standards track at right angles to Physikalisch-technische Reichsanstalt track.

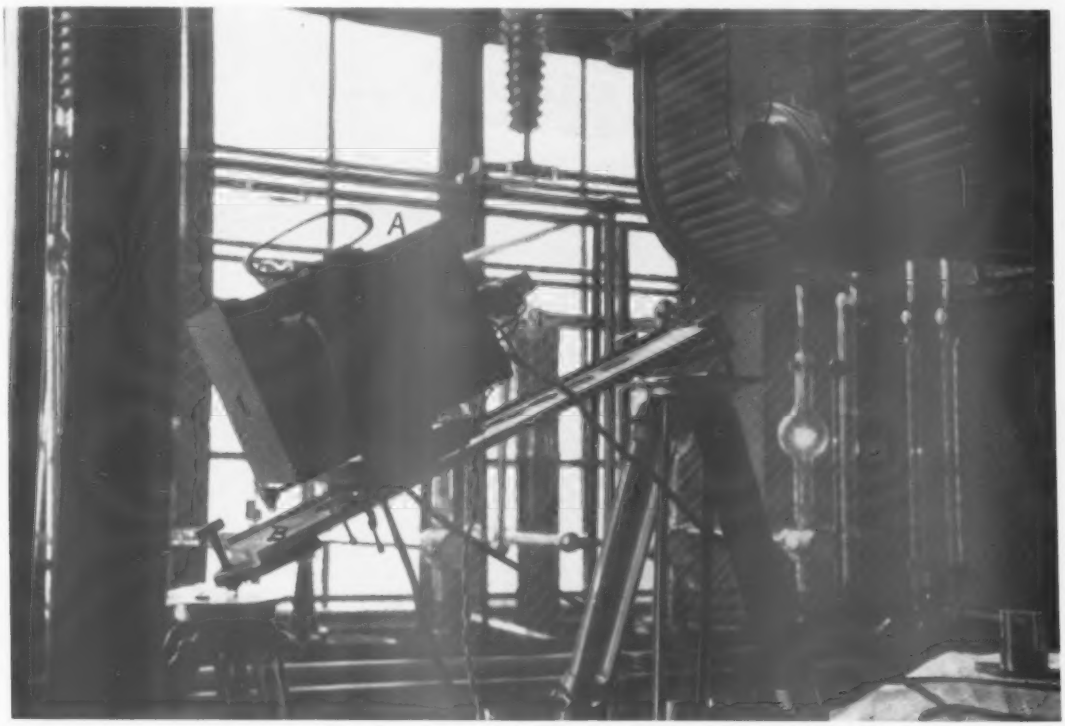

FIG. 6. Comparison of standards at Paris. *A*. Bureau of Standards chamber. *B*. Bureau of Standards track. *C*. Tube diaphragm. *E*. Solomon's ionization chamber.

sion was fairly good, and the precision of observation was to about ±0.4 per cent.

The Physikalisch-technische Reichsanstalt diaphragm system is similar in principle to that of the Bureau of Standards and it was found by measurement that their beam was uniform over a sufficient area. A comparison between their radioactive compensator and our electrostatic compensator showed a difference of 0.6 per cent which was taken into consideration in the comparison of chambers alone.

In France the centralized standardization is under the direction of Dr. I. Solomon, at l'Hôpital St. Antoine, who employs a standard thimble chamber calibrated with radium in terms of an arbitrary unit not directly comparable with the international roentgen. It was desired to establish a relationship between the French unit (R) and the international roentgen (r). It proved necessary, for securing a steadier output, to use a roentgen-ray outfit ordinarily employed for treatment. The tube was in an oil tank and so arranged that the radiation could not be taken out horizontally. As a consequence, the Bureau of Standards chamber (*A*, Fig. 6) was placed on a short track, *B*, supported by tripods and inclined at an angle of about 30°. This arrangement made alignments very difficult, invalidating, as found later, many of the observations. Furthermore, as shown in the final results, the response of the French chamber varied somewhat with the radiation quality.

The results of the comparisons with the several laboratories, relative to the Bureau of Standards guarded field chamber, are shown in Table 1. Column 2 gives the percentage difference between chambers while column 3 gives the relative size of the roentgen as defined by each chamber. The French unit cannot be compared directly with the international roentgen but the agreement with Solomon's own value at harder radiations of 1 r = 2.2 R is fairly good.

However, as a result of the measurements carried out in Paris, Dr. Solomon has adopted as his primary standard a guarded field chamber similar to that of the Bureau of Standards used in this study.

TABLE I

COMPARISONS BETWEEN STANDARDS, ALL REFERRED TO THE BUREAU OF STANDARDS GUARDED FIELD CHAMBER AS A BASE

System	Difference	Size of roentgen (1 B.S. "r" =)	Observational Error
Bureau of Standards, large	less 0.10%	1.0005 r	±0.26%
Failla (compensator)	−0.12%	1.001 r	±0.30%
England (original)	+7.50%	—	±1.00%
(final)	+0.40%	*0.996 r	±1.00%
Germany	−0.35%	1.003 r	±0.37%
France			
(Half-value layer = 0.25 mm. Cu)		2.10 R	±0.40%
(Half-value layer = 0.75 mm. Cu)		2.28 R	±0.40%
(Half-value layer = 1.00 mm. Cu)		2.29 R	±0.40%
(Half-value layer = 1.50 mm. Cu)		2.30 R	±0.40%

* This figure has been reduced to 1.001 by later measurements by Kaye. See Taylor, L. S., *Bureau of Standards J. Research*, 1932, *8*, 325.

As a result of the different comparisons, the representatives of the National Physical Laboratory, Physikalisch-technische Reichsanstalt, the Service d'Etalonnage de l'Hôpital St. Antoine, and the Bureau of Standards have drawn up a set of general requirements for national roentgen-ray standards. These are:

(1) The use of a roentgen-ray tube having a focal spot as small as possible (up to 8 mm. diameter).

(2) The use of a diaphragm placed as close to the tube as possible and having an

aperture of such size as to shield from the ionization chamber all radiation except that from the face of the target.

(3) The use of a standard chamber aperture having a minimum thickness but such that not more than 0.1 per cent of the radiation measured passes through the material of the diaphragm.

(4) The use of a standard ionization chamber aperture of about the same diameter as the focal spot—however, not to be much smaller.

(5) The utilization of only that portion of the beam in which the intensity within the experimental limits is uniform.

(6) The use of the shortest possible distance between chamber diaphragm and collector electrode.

(7) The use of a current measuring method wherein the potential difference between the guards and collector plate is negligible—preferably a null method.

On the whole, I think we must conclude that the standard measurement of the roentgen is now in a very satisfactory state and that there need no longer be any question from the physical point of view regarding its accuracy of reproduction.

I must express my great indebtedness to the men in the several national laboratories, including the Bureau of Standards, whose whole-hearted cooperation has rendered this comparison possible.

DISCUSSION

Dr. G. Failla, New York City. Dr. Taylor reports in his paper a very close agreement among the measurements of the roentgen made in Washington, London, Berlin, and Paris. Evidently the question of the unit of x-radiation is now settled so far as the different standardization laboratories are concerned. The agreement between the electrical measurements made by Dr. Taylor and those made at the Memorial Hospital was to be expected, because really no unknown factors are involved in these measurements. But since the magnitudes of the currents dealt with in this work are very small, errors might creep in unless great care is exercised.

Differences in the determination of the roentgen, or r, are due in the ultimate analysis to the diaphragm system employed in making the measurements. The agreement reported by Dr. Taylor indicates that all national standardization laboratories are now using the same diaphragm system.

Dr. Taylor (closing). The only thing which I might add is that we have used a thimble chamber in the laboratory in Washington for the purpose of watching the output of our x-ray equipment. It happens to be a Wulf ionization chamber. We have had this for about four years, and we use it for absolutely nothing except occasionally to put it in a standardized beam and check the intensity. We have found over a period of about three years that the calibration of that chamber, and I suspect any other chamber that had been treated carefully in the same way, has undergone no change whatever.

STUDIES OF THE EFFECT OF ROENTGEN RAYS ON THE TIME OF THE FIRST CLEAVAGE IN SOME MARINE INVERTEBRATE EGGS*

I. RECOVERY FROM ROENTGEN-RAY EFFECTS IN *ARBACIA* EGGS

By P. S. HENSHAW, PH.D.
NEW YORK CITY

INTRODUCTION

FOR a reliable investigation of the effects of radiations on living material, it is necessary to select for study a biological response to the radiation that will yield quantitative results. In search for such a response, the eggs of marine invertebrates have been tested. These eggs have several advantages over many of the biological test objects that have been used. During the summer months they can be obtained in great numbers from single females, thus giving uniform samples for individual experiments. Usually a variety of species are available. Most marine eggs are small, being barely visible to the unaided eye; this makes it possible to treat large numbers and obtain statistical results. Spermatozoa and eggs can be collected separately and the various samples of eggs inseminated at will, thus controlling development. Fertilization takes place quickly and uniformly, thereby insuring uniformity in early development. While carrying out some preliminary experiments a number of problems have been suggested. One of these has been investigated and will be reported here.

Our first experiment was to determine the sensitivity of some of these eggs to roentgen rays. Repeating the experiences of others who have worked with marine forms we found that such eggs were able to withstand large quantities of radiation. In fact it took around 50,000 r of unfiltered radiation to prevent the eggs of *Arbacia punctulata* from fertilizing and undergoing cleavage.

Further investigation, however, indicated that the onset of the first cleavage (measured from the time of insemination) was delayed by exposure of these *Arbacia* eggs to much smaller doses of roentgen rays before fertilization. (Throughout this report such a change resulting from exposure to roentgen rays will be referred to as *irradiation effect* or *effect*.) It was found that with an increase in dosage there was a corresponding increase in the amount of delay. By developing methods, then, for determining accurately the time of cleavage, a quantitiative measure of a biological response to radiation was at hand. Such methods have been worked out, and to the extent that maximum errors were around 10 per cent and the average around 5 per cent of the effect observed.

The ripe *Arbacia* egg prior to fertilization is developmentally inactive. Its physiological activity at this time is chiefly that of maintenance and is therefore comparatively low. However, upon the entrance of a sperm cell, development begins at once and the activity is greatly increased. In the experiments, exposure of the eggs to radiation was made before insemination and was, accordingly, at the time when they were comparatively inactive. The time required for the first cleavage to occur (the time intervening between insemination and cleavage, and henceforth called *cleavage time*) in normal *Arbacia* eggs after insemination is about fifty-five minutes at room temperature (22° – 25°C.). This temperature was used throughout in all experiments.

By plotting the different values for delay in cleavage time against the exposure time in minutes, curves were obtained similar to those shown in Figure 1. For differ-

* From the Biophysical Laboratory, Memorial Hospital, New York City, and the Marine Biological Laboratory, Woods Hole, Mass. Read at the Thirty-second Annual Meeting, American Roentgen Ray Society, Atlantic City, N. J., Sept. 22–25, 1931.

ent experiments these were found to have the same general shape but to vary somewhat in slope. By checking carefully the technique and procedure used in the different experiments, it was found that the slope of the curves varied according to the time when the samples of eggs were inseminated after irradiation. This led unexpectedly to the discovery that a process of *recovery* began very soon, if not immediately, after the radiation had been administered. For example, if a sample of eggs, which had been exposed to a certain dose of radiation, was divided into two parts and the amount of cleavage delay determined in one sample immediately after exposure and in the other one hour later, it was found to be not so great in the sample that was inseminated one hour after irradiation.

Here, then, is a biological response to roentgen rays, singled out from the many alterations of physiological processes in the organism that may have been caused by the rays, which can be measured quantitatively with a fair degree of precision, and very soon after the radiation is given. Furthermore, by inseminating the eggs at different times after irradiation, it is possible to follow the variations in effect over a period of time. As just indicated, the effect seems to be lost as time increases after irradiation. If the recovery is also measured by determining the prolongation of cleavage time, it too is obtained quantitatively and with the same degree of precision. Investigation of the process has led to some interesting results. Methods, procedure and data will be given in detail.

APPARATUS AND PROCEDURE

The roentgen tube which was used for this work was a Coolidge, tungsten target, air-cooled tube. It was maintained at 130 kv. and 5 ma. Only a light bakelite filter (approximately 1 mm. in thickness) was interposed in the beam of rays. This was mainly to protect the specimen from the radiant heat of the tube. The tube itself was enclosed in a lead box (18×18×40 inches) which served to protect the operators. In the bottom of the lead box, directly under the target, was a small opening across which were stretched two light wires. The dish containing the specimen to be irradiated was placed on the wires for treatment and when so arranged, there was a space of about 1.5 cm. between it and the

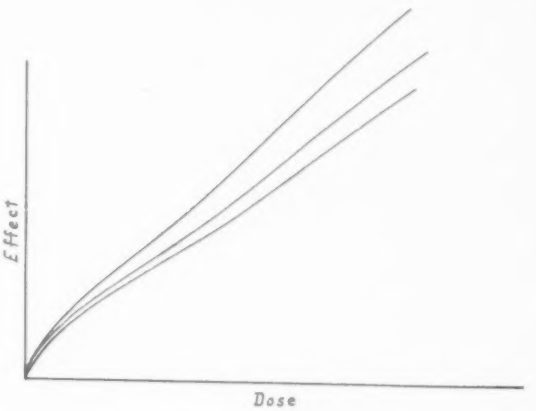

FIG. 1. Diagram showing the general relation between the amount of radiation administered (dose) and the prolongation of cleavage time (effect).

margin of the opening. Opposite this, above the tube, was another opening (about 4 cm. in diameter) to which a suction fan was attached, which provided a means for keeping the specimen at a uniform temperature. Thus, when the lead box was closed, the fan turned on, the specimen in place and the tube in operation, the hot air produced in the box by the tube was drawn off above and the specimen was maintained at room temperature by the room air being drawn in around the dish containing the eggs. The material being irradiated was 21 cm. from the target. At this point, the intensity of the beam after passing through the bakelite filter and measured in free air was found to be 520 r per minute.

The eggs and sperm were obtained from freshly collected sea urchins. They were removed from the animals by first cutting around and removing the mouth-parts from the test. With a pair of forceps the gonads (which fill most of the coelom during

the spawning season) were drawn out and shaken in a dish of sea water. If a male had been operated upon the water appeared milky and turbid, but if a female had been operated upon the water appeared reddish in color due to the eggs. Both eggs and sperm were filtered through gauze to remove any débris. The sperm suspension was diluted until the water barely appeared turbid. The eggs were then allowed to settle to the bottom and several changes of sea water were decanted to remove any body fluids that might interfere. At this stage some were removed for controls. The eight samples. One of these was inseminated at once after the respective irradiation interval ended, and the remaining seven samples at the following intervals (after irradiation), 10, 20, 40, 60, 80, 120 and 160 minutes respectively. There were then 48 samples under observation. This whole procedure is shown diagrammatically in Figure 2.

It is possible, without difficulty, to watch a sample of eggs under the microscope and determine within plus or minus four minutes when 50 per cent have cleaved. To avoid irregularities in single samples

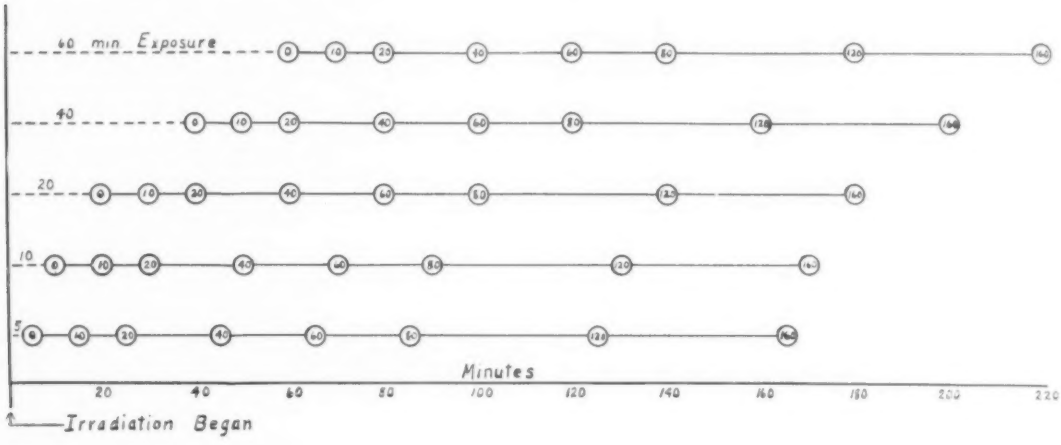

FIG. 2. Diagram showing the program of exposure and insemination of the egg samples. The dash lines represent the different durations of exposure and the circles show when portions of each sample were inseminated after irradiation.

sea water volume of the remainder was reduced to a depth of 0.5 cm. in a Stender dish, in which the eggs were irradiated.

The sample of eggs (containing several thousands), thus arranged, was taken to the roentgen tube and placed in position for irradiation as described above. Irradiation began at once and the time was noted carefully. Portions of the egg sample were removed at intervals of 5, 10, 20, 40 and 60 minutes with a small pipette (the water volume being restored after each removal). Accordingly, there were then six samples of eggs which had received doses of radiation proportional to the times of exposure. Each of these, upon receiving its full time of exposure, was subdivided immediately into and to increase the precision to plus or minus one minute, the following procedure was carried out: Each of the 48 samples mentioned above was subdivided into six Syracuse watch dishes, thus making 288 samples in all. Each group of six was arranged on the table in two rows of three dishes each. One of these samples was watched under the microscope until it appeared that 40 to 45 per cent of the eggs had divided. Then about three drops of 2 per cent formaldehyde in sea water were dropped in each of two dishes, and the time was recorded. The formaldehyde solution killed the eggs almost instantly and preserved them for future examination. The eggs in the second two dishes were killed

Table I

Min.*	Minutes Exposure					
	0	5	10	20	40	60
0	57.00	75.00	84.00	89.25	106.25	—
10	60.50	73.00	80.50	85.75	101.75	—
20	58.25	70.75	78.75	82.75	99.00	118.00
40	58.25	70.00	77.50	82.25	95.00	108.50
60	60.75	70.25	77.50	80.50	92.00	104.25
80	62.75	70.50	76.75	80.75	90.75	103.50
120	65.00	72.25	77.50	81.00	88.75	101.50
160	70.75	76.25	80.00	81.75	89.00	97.25

* Minutes after irradiation ended when eggs were inseminated.

two minutes later in the same way, and after another two minutes those in the third pair of dishes were killed. It was possible then to return to these after the eggs of all 288 samples had been similarly killed, and determine by actual counts within which two minute period each sample had reached 50 per cent cleavage. Duplicate samples in each group made it possible to avoid doubtful decisions within a single set.

Table II

Min.*	Minutes Exposure					
	0	5	10	20	40	60
0	59.8					
5	59.5	75.0				
10	59.2	—	84.0			
15	59.0	73.0				
20	59.0	—	80.5	89.2		
25	59.0	70.8				
30	59.0	—	78.8	85.8		
40	59.5	—	—	82.8	106.2	
45	59.5	70.0				
50	59.8	—	77.5	—	101.8	
60	60.5	—	—	82.2	99.0	—
65	61.0	70.2				
70	61.5	—	77.5	—	—	—
80	62.2	—	—	80.5	95.0	118.0
85	62.5	70.5				
90	63.0	—	76.8			
100	64.0	—	—	80.8	92.0	108.5
120	66.0	—	—	—	90.8	104.2
125	66.5	72.2				
130	67.0	—	77.5			
140	68.0	—	—	81.0	—	103.5
160	70.2	—	—	—	88.8	
165	70.8	76.2				
170	71.5	—	80.0			
180	72.8	—	—	81.8	—	101.5
200	74.8	—	—	—	89.0	
220	77.0	—	—	—	—	97.2

* Minutes after irradiation began when eggs were inseminated.

The actual interval between the time when the eggs were inseminated and the time of average cleavage was determined by subtraction.

RESULTS

Complete results will be given for a typical experiment. Table I presents the data which give the actual cleavage time for eggs which have received different doses of radiation and shows how the cleavage time varied following irradiation in each case. These same data are plotted graphically in Figure 3. The scale on the abscissa represents the time in minutes after irradiation began, while that of the ordinate represents the actual interval in minutes between the time of insemination and the time when 50 per cent of the eggs have cleaved. The horizontal dash lines indicate the durations of exposure for the different samples. The circles represent the actual experimental points. The lower curve in the graph (marked *0 min.*) shows the cleavage time of eggs that had not been exposed to radiation. If the irradiation effect alone is to be considered, the cleavage time of the controls at the various points must of course be deducted from the corresponding cleavage time of the irradiated eggs. The smoothest possible curve was therefore drawn through the various points for the controls, and proper values were read from this for the control cleavage times to be subtracted respectively from the actual cleavage time for the irradiated samples.* All these data are given in Table II, and the resultant values are given in Table III.

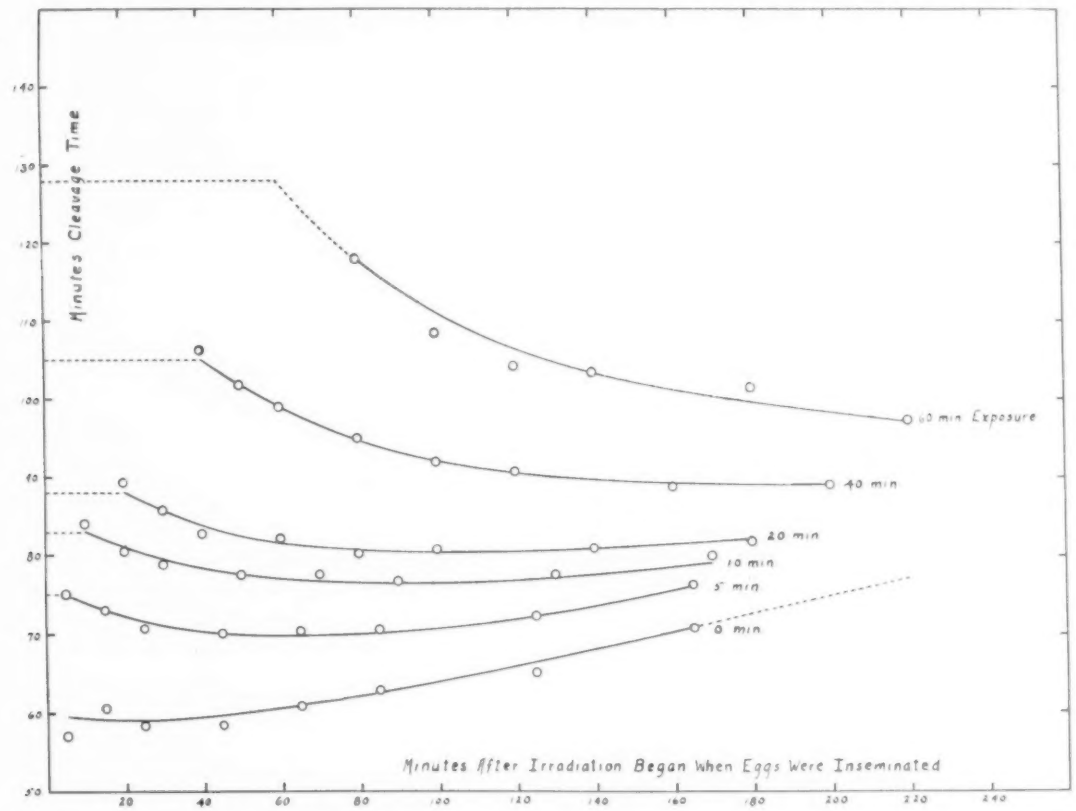

FIG. 3. Curves showing the actual cleavage time of eggs at different times for both non-irradiated samples and samples that have had different exposures of roentgen rays.

* In this particular experiment the curve for the control samples is seen to elevate considerably. In other experiments, under similar conditions, the elevation was never observed to be greater than shown here, and in some no elevation occurred.

The results are shown graphically in Figure 4, with the smoothest possible curves drawn through the points.

DISCUSSION OF RESULTS

By inspection of the curves in Figure 4, it is seen that the degree of effect, which is measured at the end of each exposure, is several different ways. For example, in Figure 4, suppose we consider a prolongation of cleavage time of twenty-five minutes. This effect may be produced by four different procedures: (1) by exposing the eggs for ten minutes and inseminating at once; (2) by exposing them twenty minutes and inseminating forty-three minutes after

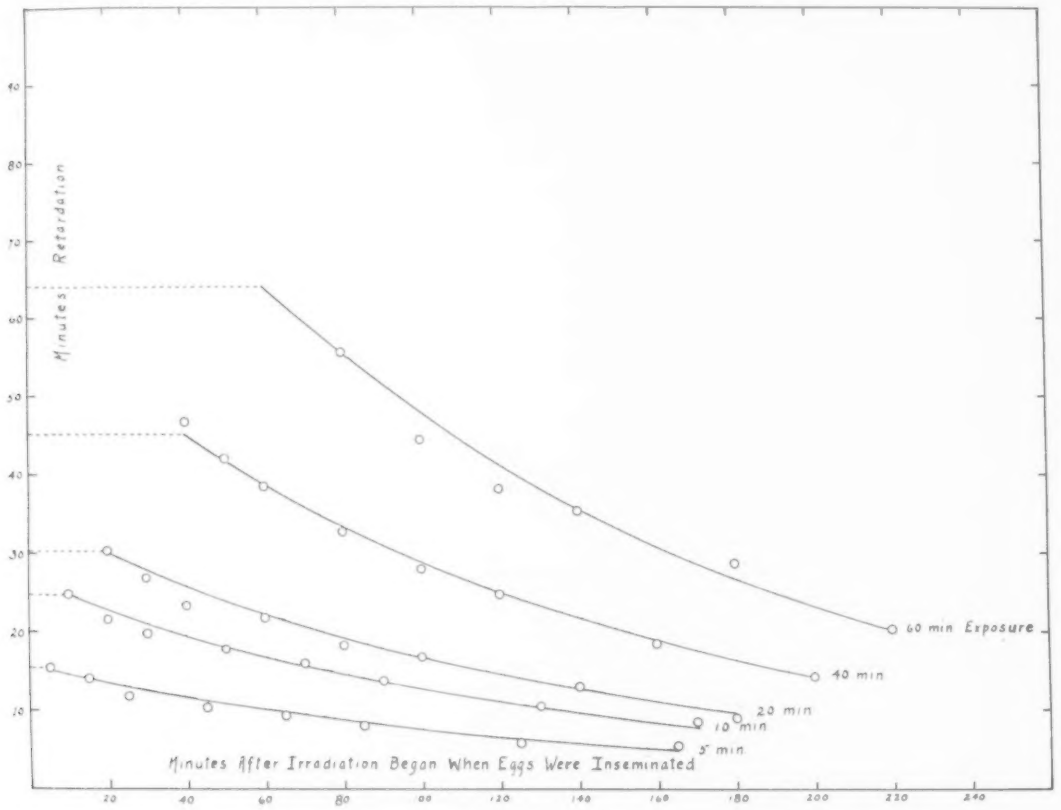

FIG. 4. The same curves as shown in Figure 3 arranged to show only the effects of the radiation on the cleavage time.

reduced as the period of time is increased between the end of irradiation and the time when the eggs are inseminated. In other words, the prolongation of cleavage time which was caused by the radiation decreases as time increases after the administration of the radiation. The radiation effect is, therefore, not only a function of the quantity of radiation given but also a function of the time during which recovery can take place. This being true, it is possible to obtain the same degree of effect in irradiation began; (3) by exposing them forty minutes and inseminating 120 minutes after irradiation began, and (4) by exposing them for 60 minutes and inseminating 190 minutes after irradiation began. Thus, it is clearly evident that recovery as well as the affecting agent must be considered. It should be stated here that the data, as presented, are based on the idea that the effect is measured at the time of insemination. In reality, it is not determined until 50 per cent of the eggs have

divided. This and other factors must be considered in interpreting the significance of these results.

In consideration of the recovery process, it is evident that the degree of effect, at any time after irradiation, will depend upon the rate at which recovery takes place. The similarity and arrangement of the curves (Fig. 4) suggest, among other things, that the rate of recovery might be the same for any degree of effect produced. This relationship between the curves may be verified by plotting these same data on semi-logarithmic graph paper. If this relationship should exist the curves will be parallel. Such a plotting is shown in Figure 5. In general they fall according to this plan, and moreover, the points for each curve fall roughly in straight lines. These relationships indicate two things in regard to the rate of recovery: (1) that it is governed by the exponential law and (2) that the rate of recovery is the same for any degree of effect produced. Such relationships are indeed exact and cannot be fully established for the process under consideration on the evidence presented here. However, that such a finding is not entirely coincidental is shown by Figure 6, which is a similar plotting of a set of data obtained from an entirely different collection of eggs on another day. Here again the data fall roughly in straight lines that are parallel.

On examining the data in these two experiments carefully, one finds an indication that a straight line through the experimentally determined points, plotted to a semi-

TABLE III

Min.*	Minutes Exposure				
	5	10	20	40	60
0					
5	15.5				
10	—	24.8			
15	14.0				
20	—	21.5	30.2		
25	11.8				
30	—	19.8	26.8		
40	—	—	23.2	46.8	
45	10.5				
50	—	17.8	—	42.0	
60	—	—	21.8	38.5	—
65	9.5				
70	—	16.0	—	—	—
80	—	—	18.2	32.8	55.8
85	8.0				
90	—	13.8			
100	—	—	16.8	28.0	44.5
120	—	—	—	24.8	38.2
125	5.8				
130	—	10.5			
140	—	—	13.0	—	35.5
160	—	—	—	18.5	
165	5.5				
170	—	8.5			
180	—	—	9.0	—	28.8
200	—	—	—	14.2	
220	—	—	—	—	20.2

* Minutes after irradiation began when eggs were inseminated.

On examining the data in these two experiments carefully, one finds an indication that a straight line through the experimentally determined points, plotted to a semi-

logarithmic scale, is not the curve that is best adapted to the points. In Figure 6 it will be found that the first and last points for each curve have a tendency to appear above the line. This would indicate that the curves should be slightly concave upward. The same tendency is present in the data for Figure 5, especially if the slight dip is not made in the beginning of the control curve of Figure 3 (which of course influences all of the values shown in Figure 5). The control curve of Figure 3 fits the data fairly well, but there are rather few experimentally determined values for it. However, considering the fact that the data as obtained were subjected to the influence of a number of factors such as experimental variation, variation in room temperature during the experiments, changes that may have occurred during the exposure time and between the time of insemination and the time when 50 per cent of the eggs divided, etc., it seems remarkable that they should conform as closely as they do to any definite organization. Whether or not the best adapted curves have precisely the character that has been assigned to them here and whether or not they have the relationship to each other that has been indicated, is perhaps not so important just now as the establishment on definite experimental evidence that recovery from *certain* irradiation injuries, at least, actually takes place in organisms in a definite way very soon, if not immediately, after the irradiation effect is produced. From the evidence available here there seems to be little doubt that this is true.

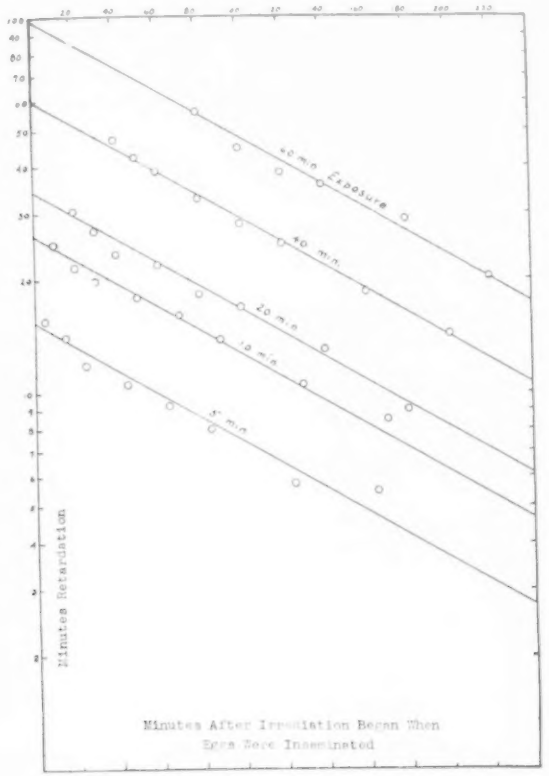

FIG. 5. The same values as shown in Figure 4 plotted to a semi-logarithmic scale.

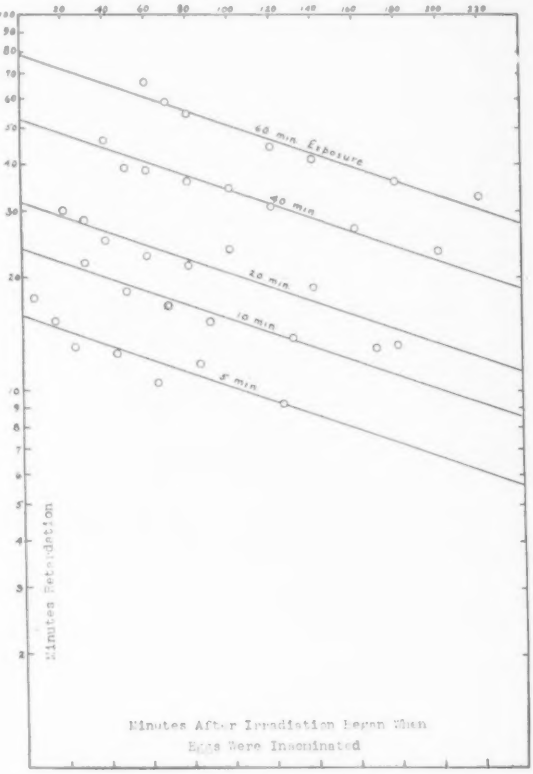

FIG. 6. A set of values similar to those shown in Figure 4 obtained from a different experiment and plotted to a semi-logarithmic scale.

SUMMARY

1. A biological response to radiation has been found in the first cleavage of the eggs of *Arbacia punctulata* which gives quantitative results with a fair degree of precision.

2. The nature of the response is such that the change resulting from the irradiation is manifest within the time required for the first cleavage to take place (measured from the time of insemination).

3. The degree of this effect has been shown to be not only a function of the radiation administered but also the time intervening between the time irradiation ends and the time insemination takes place.

4. This indicates that as soon as any irradiation effect has been produced, a process of recovery begins, which seems to be independent of the magnitude of the effect and governed by the exponential law.

I wish to express my appreciation to Dr. G. Failla for his helpful criticisms and constructive suggestions, and to Miss Dorothy Francis and Miss Doreen Smith who have assisted in carrying out the experiments.

VOL. XXVII, No. 6

LIPIODOL INJECTION OF UTERINE CAVITY IN HYDATIDIFORM MOLE

CASE REPORT

By RALPH L. LOCHRY, M.D., *St. Vincent's Hospital*
INDIANAPOLIS, INDIANA

DURING the past decade many reports have been made of the use of opaque solutions in the uterine cavity for roentgenography as an aid in diagnosis. Numerous conditions have been determined in which opaque solutions (lipiodol being the medium of choice) have helped decidedly in diagnosis. But little or no mention has been made of the condition herein reported.

Mrs. J. B., aged twenty-three, referred by Dr. H. F. Beckman. Patient came under observation December 14, 1929. Temperature, 99.6° F.; pulse, 100; blood pressure, 118/50; last period October 7, 1929. History of previous illness irrelevant to case. Menstruation began at the age of fourteen, always regular, twenty-eight day type, three days' duration, scanty flow. Since November 13 has had slight irregular bleeding, at times a gush of blood. Slight sacral discomfort, but no cramping. Nausea rather distressing, vomits frequently during the day. No headaches; no constipation. Examination of head, throat, chest and abdomen, negative.

Pelvic examination reveals uterus size of eight weeks pregnancy, sharply flexed ventrally and high in pelvis. Cervix shows slight erosion anteriorly.

Patient was confined to bed with dietary and sedative treatment for nausea and vomiting. Bleeding disappeared except for occasional spotting which at times amounted to as much as one-half ounce of blood, still without cramping or pain.

On December 24, patient was allowed to sit up in bed, when bleeding again ensued but again subsided with more complete rest. Slight bleeding again appeared during following days and inspection of cervix revealed external os somewhat patulous but internal os closed. Cervical canal was easily provoked to bleed; was treated with mercurochrome.

On January 7, 1930, patient was sent to hospital. Exposure of cervical canal showed same condition as previously, only internal os now permitted applicator to pass, and exploration of uterine cavity revealed same not completely filled with contents. It was possible to explore recessions from internal os. During all of this time discharge was watched carefully for any abnormality, but none was found. Growth of uterus was decidedly more rapid than that of normal pregnancy. No rice-like bodies having been found, and uterine cavity not being completely occupied by contents, roentgenography was resorted to in the hope that we might find

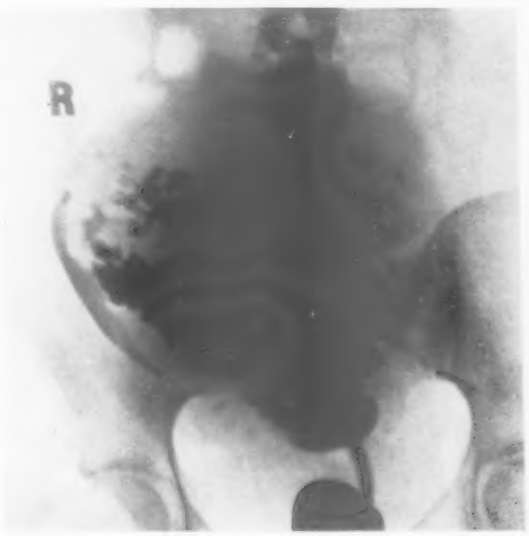

FIG. 1.

shadow of fetal skeleton. None being apparent and the patient's condition justifying surgical interference, injection of the uterine cavity was advised. The usual technique was employed and lipiodol was carefully injected. Numerous films were made during injection, the last being made after 100 c.c. had been injected. When the cannula was withdrawn three small rice-like cysts were recovered. These made diagnosis of hydatidiform mole certain.

A roentgenogram (Fig. 1) is shown and report made to add another possible use of lipiodol in uterine conditions.

The uterus was evacuated January 14, and patient made an uneventful recovery. She has had no bleeding, menstrual or otherwise, up to April 15, 1930.

FURTHER NOTE: Since reporting this case in 1930, the patient has had another pregnancy and has been delivered of a normal child, without complications.

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Publisher: CHARLES C THOMAS, 220 East Monroe St., SPRINGFIELD, ILLINOIS

Issued Monthly. Subscription $10.00 per year, $11.00 in Canada and $12.00 in foreign countries. Advertising rates submitted on application: Editorial office, 110 Professional Building, Detroit, Mich. Office of publication, 220 E. Monroe St., Springfield, Ill. Information of interest to all readers will be found on page iv.

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EDITORIAL

PRIMARY CARCINOMA OF THE LUNG

WHETHER or not the increase of primary carcinoma of the lung is actual or apparent, it occurs with sufficient frequency in every large hospital to warrant a familiarity with its various clinical manifestations, and the roentgenologist should keep constantly in mind the fact expressed by James Maxwell of London that "the thorax is assuming increasing importance as the primary site of malignant disease," and "the condition is important not only because of its malignant nature but also because it is one of the 'leaders' in the grave diseases of the lungs in persons past middle age."[1] Clinically, it is in its early stages a disease of symptoms rather than signs, and contrary to what is generally believed, it runs in many instances a chronic course, the patient giving a history of a cough with a slight expectoration of blood early in the disease. It is just these slight early manifestations which should put the examiner on his guard and he should keep constantly in mind the possibility of the process being of a malignant nature. Until we as roentgenologists become, as Manges[2] has so aptly said, "carcinoma-of-the-lung-minded" we may expect to overlook many early malignant processes in the lungs. It seems that in the literature dealing with bronchogenic carcinoma too much attention is paid to histogenesis and metastasis and too little to a description of the early changes which might be encountered in bronchogenic carcinomata. Primary carcinoma of the lung originates in the bronchial mucosa around or near the hilus of the lung and in its early stages it may not show an abnormal shadow until the growth has spread into the surrounding tissues or has grown into and obstructed the lumen of a bronchus, causing an atelectasis, simulating the roentgen appearance caused by a foreign body in the bronchus. This process may be only minimal in amount or may involve a whole lobe or an entire lung, or it may be so slight in its manifestations as to suggest only a pneumonitis in the obstructed area of the lung, or the lung may exhibit an appearance on the film of being incompletely aerated as compared with the normal side.

There is no more brilliant chapter in roentgenology than its development in connection with diseases of the chest, particularly tuberculosis, and while in this particular field of endeavor much has been accomplished, more remains still to be done. If the roentgenologist, however, applies the knowledge gained from the study of pulmonary tuberculosis to a more critical study of the films with regard to the possibility of a given process being of a malignant nature, it is not within the realm of the unreasonable to suppose that cases of primary bronchogenic carcinoma may be diagnosed earlier. While the roentgen manifestations of tuberculosis are fairly typical, those of bronchogenic carcinoma are atypical, and when the roentgen signs are atypical in a patient of carcinoma age, this should immediately attract the attention of the roentgenologist. While he may not be able to draw a definite conclusion from the roentgen appearance alone, the information gained would facilitate the diagnosis in that the patient could be subjected to intratracheal injection of lipiodol as well as bronchoscopic examination, wherein lies definitely the possibility of an early diagnosis. With a more widespread use of the bronchoscope it is to be hoped that these cases of bronchogenic carcinoma

[1] Fried, B. M. Primary Carcinoma of the Lung. Williams and Wilkins Co., Baltimore, 1932.

[2] Manges, W. F. Primary carcinoma of the lung; roentgen diagnosis and preliminary report on roentgen therapy. AM. J. ROENTGENOL. & RAD. THERAPY, June, 1932, *27*, 858–879.

will come earlier for treatment. It is true that in the treatment of bronchogenic carcinoma much also has to be done, but with the newer methods of thoracic surgery combined with radium and roentgen therapy, particularly the more recent application of radon tubes as advocated by Pancoast, Pendergrass and Tucker,[3] these hitherto fairly hopeless cases may become more amenable to treatment.

[3] Pancoast, H. K., Pendergrass, E. P., and Tucker, Gabriel. Primary bronchogenic carcinoma of the lungs; report of a new technique in radiation therapy. AM. J. ROENTGENOL. & RAD. THERAPY, March, 1932, *27*, 357–362.

Davidson, Maurice. Cancer of the Lung and other Intrathoracic Tumours. William Wood and Co., New York, 1930.

Moses, Henry M. Malignancy in the lung. *Ann. Int. Med.*, 1931, *5*, 765–792.

SOCIETY PROCEEDINGS, CORRESPONDENCE AND NEWS ITEMS

Items for this section solicited promptly after the events to which they refer.

MEETINGS OF ROENTGEN SOCIETIES*

United States of America

American Roentgen Ray Society
Secretary, Dr. E. P. Pendergrass, University Hospital, Philadelphia, Pa.
Annual Meeting: Detroit, Mich., Sept. 27-30, 1932.

American College of Radiology
Secretary, Dr. Albert Soiland, 1407 S. Hope St., Los Angeles, Calif.
Annual Meeting: Milwaukee, Wis., 1933.

Section on Radiology, American Medical Association
Secretary, Dr. G. W. Grier, Jenkins Arcade, Pittsburgh, Pa.
Annual meeting: Milwaukee, Wis., 1933.

Radiological Society of North America
Secretary, Dr. D. S. Childs, 607 Medical Arts Bldg., Syracuse, N. Y.
Annual Meeting: Atlantic City, N.J., Nov. 28-Dec. 2, 1932.

Radiological Section, Los Angeles County Medical Society
Secretary, Dr. D. R. MacColl, 2826 S. Hope St., Los Angeles, Calif.
Meets on the third Wednesday of each month at the California Hospital.

Radiological Section, Southern Medical Association
Secretary, Dr. C. H. Heacock, 20 S. Dunlap St., Memphis, Tenn.
Annual meeting: Birmingham, Ala., Nov. 16-18, 1932.

Brooklyn Roentgen Ray Society
Secretary, Dr. J. J. Masterson, 401–76th St., Brooklyn, N. Y.
Meets monthly on first Tuesday, October to April.

Buffalo Radiological Society
Secretary-Treasurer, Dr. Joseph S. Gian-Franceschi, 610 Niagara St., Buffalo, N.Y.
Meets second Monday of each month except during summer months, place of meeting selected by the host.

Chicago Roentgen Society
Secretary, Dr. George M. Landau, 660 Groveland Park.
Meeting second Thursday of each month October to May inclusive at Virginia Hotel.

Cincinnati Radiological Society
Secretary, Dr. H. G. Reineke, Christian R. Holmes Hospital, Cincinnati, Ohio.
Meetings held monthly.

Cleveland Radiological Society
Secretary, Dr. M. A. Thomas, Medical Arts Bldg.
Meetings are held at 6:15 P.M. at the Cleveland Chamber of Commerce Club rooms on the fourth Monday of each month from October to April, inclusive.

Detroit Roentgen Ray and Radium Society
Secretary, Dr. E. R. Witwer, Harper Hospital.
Meets monthly on first Thursday from October to May, at Wayne Country Medical Society Building.

Florida Radiological Society
Secretary, Dr. W. McL. Shaw, 418 St. James Bldg., Jacksonville, Fla.
Meetings held twice a year, May and November.

Illinois Radiological Society
Secretary, Dr . L. M. Hilt, Myers Bldg., Springfield, Ill.
Regular meetings held quarterly.

Indiana Roentgen Society
Secretary, Dr. J. N. Collins, Indianapolis, Ind.
Annual meeting each February 22 in Indianapolis.

Milwaukee Roentgen Ray Society
Secretary, Dr. J. E. Habbe, 221 Wisconsin Ave., Milwaukee, Wis.
Meets first Friday in October, December, February and April.
Place of meeting designated by the president.

Minnesota Radiological Society
Secretary, Dr. L. G. Rigler, University Hospital, Minneapolis, Minn.

New England Roentgen Ray Society
Secretary, Dr. Thomas R. Healy, 370 Marlboro St., Boston, Mass.
Meets monthly on third Friday, Boston Medical Library.

New York Society
Secretary, Dr. J. Bennett Edwards, Englewood Hospital Englewood, N. J.
Meets monthly on third Monday, New York Academy of Medicine, at 8:30 P.M.

Central New York Roentgen Ray Society
Secretary, Dr. M. T. Powers, 250 Genesee St., Utica, N. Y.
Three meetings a year—January, May and November.

Pennsylvania Radiological Society
Secretary, Dr. W. E. Reiley, Clearfield, Penna.
Next Meeting: Philipsburg, Pa., May 18–19, 1932.

Philadelphia Roentgen Ray Society
Secretary, Dr. Karl Kornblum, 3400 Spruce St.
Meeting first Thursday of each month from October to May inclusive, at 8:15 P.M., in Thomson Hall, College of Physicians, 19 S. 22d St.

Rochester Roentgen Ray Society, Rochester, N. Y.
Secretary, Dr. Camp C. Thomas, 476 Lake Ave.
Meets monthly on the first Friday evening at 7:45 at the Rochester Medical Association Building.

St. Louis Roentgen Club
Secretary, Dr. W. K. Mueller, University Club Bldg.
Meets first week of each month. Time and place of meetings designated by president.

Texas Radiological Society
Secretary-Treasurer, Dr. C. P. Harris, Houston, Texas.
Meets annually one day preceding the meeting of the Texas State Medical Association.

University of Michigan Roentgen Ray Society
Secretary, Dr. C. C. Taylor, University Hospital, Ann Arbor, Mich.
Meets first and third Wednesday evening of the month from October to June, at 8 o'clock in the amphitheatre of the University Hospital.

* Secretaries of Societies not here listed are requested to send the necessary information to the Editor.

VIRGINIA ROENTGEN RAY CLUB
Secretary, Dr. Wright Clarkson, 205 S. Sycamore St., Petersburg, Va.
Meets annually in October.
Next meeting: Richmond, Va., October, 1932.

CUBA

SOCIEDAD CUBANA DE RADIOLOGIA Y FISIOTERAPIA
Secretary, Dr. Francisco Padron, Enrique Villuendas 64, Havana, Cuba. Meets monthly in Havana.

BRITISH EMPIRE

BRITISH INSTITUTE OF RADIOLOGY INCORPORATED WITH THE RÖNTGEN SOCIETY
Meets on the third Thursday of each month, from November to June inclusive, at 8:15 P.M., at 32 Welbeck St., London, W. 1., or as advertised.

ELECTRO-THERAPEUTIC SECTION OF THE ROYAL SOCIETY OF MEDICINE (CONFINED TO MEDICAL MEMBERS)
Meets on the third Friday of each month during the winter at 8:30 P.M. at the Royal Society of Medicine, 1 Wimpole St., London, W. 1.

SECTION OF RADIOLOGY AND MEDICAL ELECTRICITY, AUSTRALASIAN MEDICAL CONGRESS
Secretary, Dr. H. M. Cutler, 139 Macquarie St., Sydney, New South Wales.

RADIOLOGICAL SECTION OF THE VICTORIAN BRANCH OF THE BRITISH MEDICAL ASSOCIATION
Secretary, Dr. Colin Macdonald, Lister House, 61 Collins St., Melbourne, Australia.
Meets monthly at Melbourne during the winter.

SECTION ON RADIOLOGY, CANADIAN MEDICAL ASSOCIATION
Secretary, Dr. A. H. Rolph, 160 St. George St., Toronto, Ont.

RADIOLOGICAL SECTION, NEW ZEALAND BRITISH MEDICAL ASSOCIATION
Secretary, Dr. P. C. Fenwick, The Hospital, Christchurch. Meets annually.

CONTINENTAL EUROPE

BELGIAN SOCIETY OF ROENTGENOLOGY
Secretary, Dr. J. Boine, Avenue des Allies, 134, Louvain (Belgium).
Meets monthly on second Sunday at d'Egmonds Palace, Brussels, except in the summertime.

SOCIETE DE RADIOLOGIE MÉDICALE DE FRANCE
Meets monthly on second Tuesday, except during months of August and September, 12 Rue de Seine, Paris.

SOCIÉTÉ SUISSE DE RADIOLOGIE (SCHWEIZERISCHE RÖNTGEN-GESELLSCHAFT)
Secretary for French language, Dr. A. Grosjean, La Chaux de Fonds.
Secretary for German language, Dr. Scheurer, Molzgasse, Biel.
Meets annually in different cities.

SOCIÉTÉ FRANCAISE D'ELECTROTHÉRAPIE ET DE RADIOLOGIE MÉDICALE
Meets monthly on fourth Tuesday, except during months of August and September, 12 Rue de Seine, Paris.

ASSOCIATION OF GERMAN ROENTGENOLOGISTS AND RADIOLOGISTS IN CZECHO-SLOVAKIA
Secretary, Dr. Walter Altschul, German University, Prague, II/52.

DEUTSCHE RÖNTGEN-GESELLSCHAFT (GESELLSCHAFT FÜR RÖNTGENKUNDE UND STRAHLENFORSCHUNG)
Meets annually in April, alternating one year in Berlin, one year in some other German city. Meets in addition every two years with the Gesellschaft deutscher Naturforscher und Aerzte.
Permanent secretary, Professor Dr. Haenisch, Klopstockstrasse 10, Hamburg, Germany.

SÜD-UND WESTDEUTSCHE RÖNTGENGESELLSCHAFT
Meets annually in different cities.

NORD- UND OSTDEUTSCHE ROENTGENGESELLSCHAFT
Meets annually in different cities.

DUTCH SOCIETY OF ELECTROLOGY AND ROENTGENOLOGY
Holds two meetings a year in Amsterdam, one in the Spring, and one in the Fall.

SOCIETA ITALIANA RADIOLOGIA MEDICA
Secretary, Professor M. Ponzio, University of Turin, Turin.

SOCIETATEA ROMANA DE RADIOLOGIE SI ELECTROLOGIE
Secretary, Dr. Oscar Meller, Str. Banul Maracine 30, Bucarest, Rumania.
Meets second Monday in every month with the exception of July and August.

ALL-RUSSIAN ROENTGEN RAY ASSOCIATION, LENINGRAD, USSR in the State Institute of Roentgenology and Radiology, 6 Roentgen St.
Secretaries, Drs. S. A. Reinberg and S. G. Simonson.
Meets annually.

LENINGRAD ROENTGEN RAY SOCIETY
Secretaries, Drs. S. G. Simonson and G. A. Gusterin.
Meets monthly, first Monday at 8 o'clock, State Institute of Roentgenology and Radiology, Leningrad.

MOSCOW ROENTGEN RAY SOCIETY
Secretaries, Drs. L. L. Holst, A. W. Ssamygin and S. T. Konobejevsky.
Meets monthly on the first Monday at 8 o'clock, the place of meeting being selected by the Society.

POLISH SOCIETY OF RADIOLOGY
Secretary, Dr. Jan. Kochanowski, 45 Gornoslazka St., Warsaw. Meets annually.

WARSAW SECTION, POLISH SOCIETY OF RADIOLOGY
Secretary, Dr. B. Krynski, 11 Zielna St.
Meets once a month except in the summertime.

SCANDINAVIAN ROENTGEN SOCIETIES
The Scandinavian roentgen societies have formed a joint association called the Northern Association for Medical Radiology, meeting every second year in the different countries belonging to the Association. Each of the following societies, with exception of the Denmark Society, meets every second month except in the summertime.

SOCIETY OF MEDICAL RADIOLOGY OF SWEDEN
Meets in Stockholm.

SOCIETY OF MEDICAL RADIOLOGY IN NORWAY
Meets in Oslo.

SOCIETY OF MEDICAL RADIOLOGY IN DENMARK
Secretary, Dr. G. Biering, Copenhagen.
Meets on the second Wednesday of each month from October to July in Copenhagen, at 8 o'clock in the State Institute of Roentgenology.

SOCIETY OF MEDICAL RADIOLOGY IN FINLAND
Meets in Helsingfors.

VIENNA SOCIETY OF ROENTGENOLOGY
Secretary, Professor Holzknecht, Vienna, IX, General Hospital.
Meets first Tuesday each month, October to July.

ORIENT

JAPAN X-RAY ASSOCIATION
c/o Orthopedic Surgery, Tokyo Imperial University.
Meets annually in April.

KINKI ROENTGEN-ABEND SOCIETY
Director, Dr. Prof. Taiga Saito, Ogawaoike Tyoto, Japan. Meets bi-monthly on third Sunday.

AMERICAN ROENTGEN RAY SOCIETY

THIRTY-THIRD ANNUAL MEETING

A trite saying is "In times of peace, prepare for war." It has been suggested that medical men in times of quiet should fit themselves for the period when professional demands make it difficult to keep abreast with the advances in their particular field. So now, when there is a relatively limited demand for our services, we should take advantage of opportunities for instruction and for extending our experiences.

Such an occasion will be the coming meeting of the American Roentgen Ray Society to be held at the Book-Cadillac Hotel, Detroit, Michigan, September 27 to 30, 1932. Those in charge of the arrangements are planning a scientific program that will bring to those in attendance the latest information on a variety of subjects through men particularly well qualified.

Many outstanding pathologists have stated that the diagnosis of bone lesions is mainly a roentgenological responsibility. Phthisiologists have finally accepted roentgen diagnosis of pulmonary lesions as a method possessing advantages over every other procedure and the new active therapeutic measures place still greater responsibilities upon the roentgenologist.

Physicians engaged in industrial medical practice and the frequently associated court and compensation demands are looking more and more to roentgenologists for diagnostic and prognostic guidance.

Gynecologic practice is being revolutionized by the application of diagnostic and therapeutic methods involving the use of roentgen rays and radium. And so on and on into practically every phase of medical activity.

The scientific exhibit and the papers and discussions being planned will afford those attending the various sessions an opportunity to better fit themselves for the ever increasing demands being made on our specialty, and in the way of encouragement it can be stated that the hotel management is fully conscious of the economic conditions and their rates have been reduced accordingly.

For these and many other reasons, it is hoped that those planning the Thirty-third Annual Meeting of the American Roentgen Ray Society may expect the active interest and attendance of everyone interested in roentgenology.

William A. Evans
President-elect

SYMPOSIUM ON X-RAYS AND RADIUM

The American Association for the Advancement of Science will hold its summer meeting in Syracuse, New York, June 20 to 25, 1932. On Friday, June 24, a symposium on X-rays and Radium will be held. The following papers will be presented in the symposium:

1. "Differential Action of X-rays, and its Bearing on Cancer Therapy." Dr. G. Failla, Memorial Hospital, New York City.
2. "The Significance of Proper Physical Measurements in Interpreting the Biological Action of X-rays." Dr. Lauriston S. Taylor, Bureau of Standards, Washington, D. C.
3. "Effect of X-rays on Germ Cells and Heredity." Dr. James W. Mavor, Union College, Schenectady, N. Y.
4. "Clinical Observations on the Relative Value of Radium and X-rays." Dr. Douglas Quick, New York City.
5. "Roentgen Therapy in Cancer." Dr. R. E. Herendeen, New York City.
6. "On the Nature of the Action of X-rays on Living Tissues (Blood Forming Cells)." Dr. Raphael Isaacs, Simpson Memorial Institute for Medical Research, Ann Arbor, Mich.
7. "The Death of Yeast Cells by X-rays." Dr. Otto Rahn and M. N. Barnes, Cornell University, Ithaca, N. Y.
8. Topic not stated. Dr. R. W. G. Wyckoff, Rockefeller Institute for Medical Research, New York City.
9. "Some Quantum Calculations on X-ray Therapy." Dr. Wheeler P. Davey, Pennsylvania State College, Penna.

FLORIDA RADIOLOGICAL SOCIETY

The regular annual meeting of the Florida Radiological Society was held in Sarasota, Florida, May 2, 1932, at the Sarasota Terrace Hotel. Dr. Lester W. Cunningham, Jacksonville, President of the Society, presided. Informal presentation of case reports and demonstration of interesting roentgenograms featured a morning and afternoon session. The following officers were elected to serve until the spring meeting, 1933: President: Dr. Orion O. Feaster, St. Petersburg; Vice-President: Dr. Frederick K. Herpel, West Palm Beach; Secretary-Treasurer: Dr. W. McL. Shaw, Jacksonville.

X-RAY FILM AS THE PROPERTY OF THE PHYSICIAN

Mary Thocker, Plaintiff,	4-4-32.
—vs—	Ingham County Circuit
S. V. Barnum, M.D. &	Court.
R. A. Pinkham. M. D.	State of Michigan.
Defendants.	Judge Leland W. Carr.

CHARGE TO THE JURY

THE COURT:

Gentlemen of the Jury, This is rather an interesting case in some of its aspects. But as I view the situation it resolves itself into a question of law.

Now it appears that these x-ray films were taken by Dr. Pinkham; he had them in his possession at the time that this action was instituted. There is, however, no showing in the case that these x-ray films at the time of the institution of the suit or at the present time had or have any intrinsic value whatever. Replevin lies to recover property that has value. It will not lie to recover something that has no value, and as I say there is no proof of value concerning these x-ray pictures or films.

And then we come to the question, passing by this matter of failure to prove value. When x-ray films or pictures are taken by a physician, is there any implied undertaking on the part of the physician taking such pictures that they will be turned over to the patient? The undisputed evidence in this case is to the effect that it is customary that such films be retained by the physician who has taken them,—retained by him as a part of his record concerning the case; retained, I suppose, on the same basis and on the same theory that he retains his temperature chart that he has made or other record concerning the diagnosis or treatment of a case. That testimony stands undisputed in this record. I think it must be conceded that it establishes an uncontradicted custom touching and concerning the subject matter of this case. And that as a matter of law it must be said that where x-ray pictures are taken by a physician under the circumstances such as they were taken under by Dr. Pinkham in this case, there is no implied undertaking to turn those films over to the patient.

It becomes the duty of the court therefore to direct you to return a verdict of not guilty as to both defendants and the clerk will receive the verdict.

INDEX TO ABSTRACTS

ROENTGEN DIAGNOSIS

Neck and Chest

Dunhill, T. P.: Carcinoma of the thyroid gland ... 908

v. Pannewitz, G. Partial deglutition paralysis as a roentgen symptom in diseases of the esophagus ... 908

Schatzki, R.: The roentgen diagnosis of esophageal and gastric varices and their clinical significance ... 908

Popp, Leonida: A case of gastric burn from caustic soda without marked lesions of the esophagus ... 909

Adams, W. E., and Livingstone, H. M.: Obstructive pulmonary atelectasis ... 909

Gilbert: Research on the frequency of accessory lobe of the vena azygos in systematic roentgenoscopic examinations for drafting of the army ... 909

Lamarque and Betoulières: Some images of azygos lobe, one of them of a hereditary character ... 909

Jalet, J.: Some cases of pathologic azygos lobes ... 909

Le Bourdellès, B., and Jalet, J.: The roentgen aspects of the scissura and of the azygos lobe in pulmonary tuberculosis ... 910

Businco, Ottavio, and Cardia, Antonio: On the distribution of experimental pulmonary emboli in the roentgenogram ... 910

Meller, Oskar, and Menkes, B.: Experimental investigations on the roentgen visualization of pulmonary connective tissue. 910

Danelius, Gerhard: Roentgenology of the upper medial portions of the lung ... 911

Bársony, Theodor, and Koppenstein, Ernst: Contributions to the shadow formations in the upper lung field ... 911

Zdansky, Erich: Roentgen findings in the lungs in bronchial asthma ... 911

Findlay, Leonard, and Graham, Stanley: Prognosis in bronchiectasis ... 911

Bönniger, M.: A test grid for lung exposures and the limit of roentgen visualization of finer tuberculous foci ... 912

Sweany, Henry C., Cook, Carol E., and Kegerreis, Roy: A study of the position of the primary cavities in pulmonary tuberculosis ... 912

Doolittle, S. E.: A study of tuberculosis in one junior high school in Honolulu ... 912

Darbois, and Sobel: Certain roentgenologic aspects of pulmonary syphilis ... 912

McIntyre, Mary C.: Pulmonary syphilis ... 913

Egas Moniz, Lopo de Carvalho, and Almeida Lima: Angiopneumography ... 914

Abdomen

Gutman, René A., and Nemours-Auguste: A simple procedure for studying the folds of the gastric mucosa ... 915

Hayer, E.: The visualization of the gastric relief in the supine position ... 915

Imbert, René: Linitis and gastric calcification 915

Gröninger, J.: The roentgen symptomatology of the operated stomach ... 915

Oppenheimer, Albert: The roentgen signs of so-called chronic appendicitis ... 916

Schmidtlein, Ernst: On the active mobility and the mechanism of evacuation of the appendix ... 916

Piot, Etienne, and Picarda, J.: Roentgen contribution to the diagnosis of appendicitis and ileocecal perivisceritis ... 917

Skeletal System

Schmorl, G.: Anatomic findings in a case of osteopoikilosis ... 917

Lyon, Ernst, and Marum, Gottlieb: Diseases of the epiphyses of the vertebral body ... 918

Janker, Robert: Persisting apophyses of the vertebral column ... 918

Böhmig, R., and Prévôt, R.: Comparative examinations on the pathology and roentgenology of the spinal column ... 918

Dausset: A new case of calcified nucleus pulposus ... 919

Wagoner, George, and Cohen, Bernard N. E.: Osteochondritis dissecans ... 920

Schwentker, Francis F.: Cystic tuberculosis of the bone ... 920

Neale, A. Victor, and Allen-Price, E. D.: Chondrosarcoma of the fibula ... 921

Seifert, E.: Some misformations in the shoulder joint ... 921

Behr, F.: On familial shortening of the fingers, brachydactyly, clinodactyly ... 921

Duggan, LeRoy B., and Bromberg, Leon: Syphilis of bone resembling osteitis deformans ... 921

Petrignani, Roger: Evolutive and stabilized forms of Pellegrini-Stieda's disease ... 921

Gavrilescu, Stelian G.: Metatraumatic internal paracondyloid ossification of the femur. Pellegrini-Stieda's disease ... 922

Politzer, G.: On malformations of the hand and foot skeleton and their formal genesis. 922

HARMON, PAUL H., and MCKENNA, HUGH: Primary myelogenous sarcoma complicating cystic disease of the humerus..... 922

Blood and Lymph System

SGALITZER, M., KOLLERT, V., and DEMEL, R. Visualization of the veins in the roentgenogram by means of a contrast medium 923

General

BRAILSFORD, JAMES F.: Hydatid disease in England..... 923

JAUBERT DE BEAUJEU, A., and BLOCH, E. A case of Klippel-Feil's syndrome..... 924

ROENTGEN AND RADIUM THERAPY

TALIA, FERDINANDO: Intrathoracic goiter with severe stenosis of the esophagus and trachea cured by roentgen rays..... 924

HOLFELDER, HANS: Local by- and after-effects of roentgen rays..... 925

MELDOLESI, GASTONE: Roentgen diagnosis and treatment of bone metastases from epithelioma of the breast and uterus..... 926

GLOOR, WALTHER, and ZUPPINGER, ADOLF: Blood examinations in protracted fractional irradiation..... 926

ABSTRACTS OF ROENTGEN AND RADIUM LITERATURE

ROENTGEN DIAGNOSIS

NECK AND CHEST

DUNHILL, T. P. Carcinoma of the thyroid gland. *Brit. J. Surg.*, July, 1931, *19*, 83–113.

The pathology of carcinoma of the thyroid is discussed. The author's classification is simple, comprising the scirrhous type, the papilliferous adenocarcinoma, and the malignant adenoma. The first named type is very rare. Thyroid epithelium undergoes hyperplasia either in the attempt to cope with demands made upon it or as a response to stimulation, and this proliferation may be either papilliferous or follicular in type. The author suggests that the degree of proliferation determines whether we are dealing with a condition which appropriate treatment would relieve, with a benign neoplasm, or finally, with invading or disseminating growths. Those assuming a papilliferous type of hyperplasia may become the papilliferous adenocarcinoma while the follicular type leads to malignant adenoma.

The author's experience with roentgen therapy is very encouraging, 14 cases being treated with decided benefit, taking into consideration the slow rate of growth of these tumors. Two cases were treated with radium. Treatment should consist of surgical removal where possible, followed by roentgen therapy. The latter without previous surgery seemed to be of no avail.—*F. H. Decker.*

v. PANNEWITZ, G. Partielle Schlucklähmung als Röntgensymptom bei Erkrankungen des Ösophagus. (Partial deglutition paralysis as a roentgen symptom in diseases of the esophagus.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Aug., 1931, *44*, 170–177.

The author studied a series of 50 cases of various esophageal lesions and found that in 38.6 per cent there was a prolonged sojourn of the contrast mixture at the level of the valleculae epiglotticae and sinus piriformes due no doubt to partial paralysis of the muscular elements of the pharynx, the so-called "pharyngeal paresis." The phenomenon was observed chiefly in case of neoplasms. It is the author's contention that its visualization is of considerable practical importance.—*T. Leucutia.*

SCHATZKI, R. Die Röntgendiagnose der Ösophagus- und Magenvarizen und ihre Bedeutung für die Klinik. (The roentgen diagnosis of esophageal and gastric varices and their clinical significance.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, July, 1931, *44*, 28–39.

The author describes 5 cases of varices of the esophagus and cardiac end of the stomach using several roentgenograms for illustration. The following conclusions are reached: The method of examination must conform to the individual case, the consistency of the barium suspension being varied according to Berg. The roentgen appearance is that of a disturbance of the normal relief of the esophageal mucosa, with tortuosities, branchings and rounded areas of increased translucency which by full filling of the esophagus are occasionally visualized as thin marginal bands. There is a retardation of the passage and especially of the "clearing" of the esophagus in the involved area. The constancy of this phenomenon at several successive examinations is most important. In contradis-

tinction to malignancy, the esophagus maintains its normal expansibility.—*T. Leucutia.*

Popp, Leonida. Un caz de arsura gastrica prin soda caustica, fara leziuni remarcabile la oesofag. (A case of gastric burn from caustic soda without marked lesions of the esophagus.) *Cluj med.*, Oct. 1, 1931, *12*, 546–548.

The swallowing of caustic soda, as is known, results in the majority of instances in a "cicatrizing stenosis" of the esophagus. The cases in which the esophagus remains more or less intact but the burn is localized chiefly to the stomach are rare. The author was able to observe such a case in a girl twenty-three years of age, who swallowed caustic soda in a suicidal attempt, and he now presents the roentgen findings. The interesting feature is that the patient concealed the history of poisoning so that the diagnosis was made purely on the roentgen appearance.

Based on the observation of this case, the author distinguishes between two stages of the gastric burn: (1) the stage of ulcerations lasting three to four weeks and (2) the stage of cicatrization beginning after four weeks. In the first, the picture is dominated, as a rule, by the esophageal manifestations while in the second a gradual stenosis develops. If the involvement is localized chiefly to the pyloric region the resulting stenosis gives an identical appearance with that of the stenosis produced by simple juxtapyloric ulcers. If, however, the involvement is confined to the prepyloric region, the roentgen picture may be that of a neoplasm. This latter was encountered in the author's case. A differentiation was made on the basis of the comparative youth of the patient as well as on the fact that the border of the defect appeared sharp and regular. A closer questioning of the patient later resulted in the admission that she had swallowed caustic soda four weeks previously. A gastroenterostomy led to complete disappearance of the symptoms, a checkup examination three years later revealing a normal function of the stomach.

The apparent non-involvement of the esophagus is explained by the fact that the patient had swallowed a very weak solution of soda, the rapid passage through the esophagus preventing a burn whereas the longer sojourn in the lower part of the stomach (prepyloric region) produced the above described findings.—*T. Leucutia.*

Adams, W. E., and Livingstone, H. M. Obstructive pulmonary atelectasis; further studies. *Arch. Surg.*, Sept., 1931, *23*, 500–512.

Three series of experiments on dogs are related to determine the cause of obstructive pulmonary atelectasis. It was found that if the main bronchus of any lobe was sufficiently treated with a strong solution of silver nitrate bronchoscopically, complete stenosis of the bronchus occurred eventually, followed by complete atelectasis of the distal lobe. If a secondary bronchus was so treated, producing complete stenosis, there was retained secretion and dilated distal bronchi but no atelectasis was produced in the alveoli. In the third experiment, it was found that the type of respiration played no part in the production of atelectasis, disproving a previous publication of the authors on this subject.

These experiments are in accord with another recent publication that, at least in the dog, there may be collateral circulation of air from one lobule to another.—*R. R. Rathbone.*

Gilbert. Recherche de la fréquence du "lobule accessoire" de la veine azygos, à l'occasion des examens radioscopiques systématiques pour le recrutement de l'armée. (Research on the frequency of accessory lobe of the vena azygos in systematic roentgenoscopic examinations for drafting of the army.) *Bull. et mém. Soc. de radiol. méd. de France*, March, 1931, *19*, 99–100.

During a period of eight years 5 cases of azygos lobe were demonstrated in 1000 systematic examinations of the chest in recruits. This gives an incidence of 5 per thousand.—T. *Leucutia.*

Lamarque and Betoulières. Quelques images de lobe azygos dont un cas à caractère héréditaire. (Some images of azygos lobe, one of them of a hereditary character.) *Bull. et mém. Soc. de radiol. méd. de France*, July, 1931, *19*, 358–359.

The authors observed 4 cases of azygos lobe in a total of 200 pulmonary examinations, an incidence of 2 per cent, which is considerably higher than usually found. In one of the cases the condition occurred in father and son, thus being of a hereditary character.—*T. Leucutia.*

Jalet, J. Quelques das de lobes azygos pathologiques. (Some cases of pathologic azygos

lobes.) *Bull. et mém. Soc. de radiol. méd. de France*, July, 1931, *19*, 330–331.

Azygos lobe was considered for a number of years as a simple anatomic malformation. The author presents 5 cases in which pathologic changes were present. In the first a diagnosis of glandular enlargement and encysted pleural effusion of the apex was made; in the second a pulmonary cavity was suggested, although no clinical symptoms were present; in the third the azygos lobe was associated with cavitary tuberculosis of the same side, a therapeutic pneumothorax leading to collapse of all lobes with the exception of the azygos lobe; in the two other cases a pachypleuritis was demonstrated.—*T. Leucutia.*

Le Bourdellès, B., and Jalet, J. Les aspects radiologiques de la scissure et du lobe azygos dans la tuberculose pulmonaire. (The roentgen aspects of the scissura and of the azygos lobe in pulmonary tuberculosis.) *Presse méd.*, Nov. 7, 1931, *39*, 1623–1625.

Former studies have shown that pulmonary tuberculosis, when localized chiefly to the interstitial connective tissue and to the lymphatic system of the lungs, leads in the course of its propagation to involvement of the interlobar septa (the so-called tuberculous scissuritis). On the other hand, the septa, by having served as barriers against the extension of the exudative process, may become the seat of a beginning reactivation of the tuberculosis.

The authors investigated the changes of the septa (scissura) of the azygos lobe secondary to tuberculosis and, based on a study of 15 cases (out of a total of 580 roentgenograms of pulmonary tuberculosis), arrived at the following conclusions: (1) one may observe the co-existence of a tuberculous focus with the normal image of an azygos septum; (2) the normal image of the azygos septum may be obscured by the presence of a parenchymatous lesion (in one case the azygos lobe was diagnosed only after therapeutic pneumothorax); (3) a tuberculous involvement of the septum (the so-called scissuritis or still better meso-scissuritis of the azygos lobe) is encountered quite frequently, the image sometimes suggesting false cavitation of the apex; (4) the tuberculosis may involve the azygos lobe (the so-called azygos lobitis), and (5) the azygos septum may form a barrier arresting the propagation of the tuberculous process.

The authors wish to state, however, that they have not yet had the occasion to confirm the above clinical findings by post-mortem examinations.—*T. Leucutia.*

Businco, Ottavio, and Cardia, Antonio. Über die Verteilung der experimentellen Lungenembolie im Röntgenbild. (On the distribution of experimental pulmonary emboli in the roentgenogram.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, July, 1931, *44*, 60–69.

The authors performed a series of experiments to determine the distribution of pulmonary emboli in dogs following the injection of opaque substances. Eight cubic centimeters of a 20 per cent oily mixture of bismuth were injected into the jugular or femoral vein after morphinization and roentgenograms taken every fifteen to twenty seconds until exitus, which occurred within five to fifteen minutes.

It was found that the injected material had reached the lungs in twenty to thirty seconds, distributing itself chiefly in the basal parts and leading to complete filling of both lower lobes within sixty to ninety seconds. The material penetrated in the majority of instances first the right lower lobe and only afterwards the left. In case of horizontal position the gravity of the injected material had an evident influence on the seat of localization. It seems thus that there is a definite relationship between the origin and distribution of the emboli in the lungs.—*T. Leucutia.*

Meller, Oskar, and Menkes, B. Experimentelle Untersuchungen über die Röntgendarstellbarkeit des Lungenbindegewebes. (Experimental investigations on the roentgen visualization of pulmonary connective tissue.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Aug., 1931, *44*, 197–204.

The authors performed a series of experiments on lung specimens of children from four to nine years of age to determine the degree of roentgen visibility of the pulmonary connective tissues. For this purpose they soaked the inflated lungs taken at autopsy (after first making a roentgenogram) in 5 per cent acetic acid solution for a period of twenty-four hours, and then roentgenographed them. As is known the acetic acid solution greatly swells the connective tissue. The comparative roentgenograms revealed an accentuation of all the lung markings with excellent detail. The article is richly illustrated with roentgenograms and photographs

of the lung specimens as well as with several photomicrographs showing the connective tissue changes.—*T. Leucutia.*

Danelius, Gerhard. Röntgenologie der oberen medialen Lungenabschnitte. (Roentgenology of the upper medial portions of the lung.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Nov., 1931, *44*, 626–634.

The author published in a previous article (see abstract this Journal, 1930, *23*, 96) the results of his experimental investigations on the upper borders of the lungs, as demonstrated roentgenologically. There, the conclusion was reached that parts of the medial portions of the upper lobes are hidden by the mediastinum and spine and that consequently lesions occurring in this region may escape roentgen detection. In the present article the author publishes a technique of examination by which this may be obviated. The patient is placed in a lateral erect position with the arm (on the side against the cassette) raised above the head and the central ray is directed through the supraclavicular fossa of the opposite side emerging in the axilla of the side against the cassette.

It was found that the retroesophageal space changes its configuration considerably during respiration as a result of filling of the hidden parts of the lungs with air. The best roentgenograms are obtained in deep inspiration. No difference was observed in changing from the erect to the horizontal position.—*T. Leucutia.*

Bársony, Theodor, and Koppenstein, Ernst. Beiträge zu den Schattenbildungen im oberen Lungenfeld. (Contributions to the shadow formations in the upper lung field.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Sept., 1931, *44*, 320–335.

Routine dorsoventral films of the chest often show in the apical region, in addition to the linear shadow accompanying the second rib and corresponding to the pleural cap, a second linear shadow starting from the first rib laterally and running obliquely medially (the so-called "medial-oblique shadow") which most probably corresponds to the depression of the apex. Both of these shadows are normal. They are especially well visualized in the films taken with ventrodorsal, caudocranial incidence.

In the daily examinations one may encounter also other shadows which are normal. Thus in the lateral view a triangular shadow with median caudalward striations is not infrequently observed in the region of the apices, corresponding to an atypical mediastinal space. On the other hand, the rounded shadow of the median angle of the scapula produced by the insertion of the musculus serratus anterior may lead to intensification of an eventual area of infiltration. An increased translucency from a very deep supraclavicular fossa may produce confusion with a peripheral cavity whereas the insertion of the sternocleidomastoid muscle on the first rib may simulate a pleural band.—*T. Leucutia.*

Zdansky, Erich. Lungen-Röntgenbefunde bei Asthma bronchiale. (Roentgen findings in the lungs in bronchial asthma.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, May, 1931, *43*, 576–593.

The systematic roentgen examination of the chest in 70 cases of bronchial asthma revealed the following findings: Cases of severe asthma without emphysema are not rare; increased bronchial markings are observed as a result of thickening of the bronchial walls from chronic bronchitis; adhesions of the diaphragm and mediastinum are frequently encountered. Of the nonspecific processes, there may occur (*a*) indurative thickening with or without bronchiectasis, (*b*) indurative thickening with fresh infiltrative processes, (*c*) circumscribed infiltrations which may produce no clinical symptoms, (*d*) miliary foci due to bronchiolitis, (*e*) numerous various sized areas of confluent infiltrations, not infrequently presenting a peribronchial arrangement, as the result of advanced bronchitis.

Tuberculous changes were observed in 50 per cent of all asthmatics, which is not a larger percentage than that of non-asthmatics of the same age and social position. Likewise the type and course of the tuberculous manifestations remained uninfluenced, tuberculous cavities, for example, occurring as frequently as in non-asthmatics. A tuberculous allergic genesis of bronchial asthma could not be demonstrated.

Changes in the hilar glands were found only rarely and then mostly in the cases with tuberculous complications. It appears, therefore, that the effect of pressure of the enlarged hilar glands in provoking bronchial asthma is questionable.—*T. Leucutia.*

Findlay, Leonard, and Graham, Stanley. Prognosis in bronchiectasis. *Arch. Dis. Childhood*, Feb., 1931, *6*, 1–10.

The authors rely upon the intratracheal injections of lipiodol as a routine aid in the diagnosis of bronchiectasis. They have observed 32 definite examples of this disease, of which 7 have died from bronchiectasis and 5 from operative interference or other complications. Fourteen cases have been observed from three to six years and in 3 of these where the degree of dilatation was slight the preexisting bronchiectatic condition disappeared. Their experience differs from those of Nobecourt and Hutinel in that the healed cases revealed an average age of onset which was several years later than the average age of the whole series. The prognosis is grave and the duration of the illness is of no prognostic aid.—*F. H. Decker.*

BÖNNIGER, M. Ein Testraster für Lungenaufnahmen und die Grenzen der röntgenologischen Darstellbarkeit feinerer tuberkulöser Herde. (A test grid for lung exposures and the limit of roentgen visualization of finer tuberculous foci.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, July, 1931, *44*, 108–113.

The author constructed a grid consisting of parallel aluminum strips 1 mm. wide (of from 0.2 to 0.3 mm. thickness) embedded at 1 cm. distance from each other in cardboard. This is placed on the roentgen cassette during the roentgenography of the chest. The method has the advantage that the aluminum strips which in normal individuals show only faintly permit a comparison of the quality of roentgenograms taken at various intervals and of the anatomic specimens of the lungs with the original roentgenograms. It was found that very small tuberculous foci which appeared plainly in the roentgenograms of anatomic specimens failed to visualize in roentgenograms in the living, thus indicating that roentgenography has a limited value in the very early cases of tuberculosis.—*T. Leucutia.*

SWEANY, HENRY C., COOK, CAROL E., and KEGERREIS, ROY. A study of the position of the primary cavities in pulmonary tuberculosis. *Am. Rev. Tuberc.*, Nov., 1931, *24*, 558–582.

In this study a method of geometrical localizations from stereoscopic roentgenograms of pulmonary cavities is used. Two hundred and sixty-eight cavities were measured in 204 cases with respect to size, posterior rib level, percentage removed from the median line, and the percentage situated posteriorly. The cavities were situated mostly in the posterior and outer part of the upper lobes and the apices of the lower lobes. About 98 per cent of early cavities seem to be situated on bronchi that are directed rather sharply posteriorly. Most cavities are situated 1.5 to 3 cm. beneath the pleura corresponding to the fourth and fifth order of bronchi and consequently nearly all are "infraclavicular."—*J. M. Hilton.*

DOOLITTLE. S. E. A study of tuberculosis in one junior high school in Honolulu. *Am. Rev. Tuberc.*, Nov., 1931, *24*, 491–521.

Of 1,437 students (of age group eleven to eighteen years and above) 75 per cent gave positive tuberculin reactions with cutaneous and intracutaneous tests carried to doses of 1 mg. Roentgen examination of all positive reactors revealed 13 cases of adult pulmonary tuberculosis, and 175 lesions of the childhood type (including pleurisy). Nearly all of the later group were latent or nearly healed. The lesions demonstrable in roentgenograms were practically identical in the two sexes. There was a higher rate of infection among the Chinese. "Home contacts" showed ten times as many positive reactors.—*J. M. Hilton.*

DARBOIS and SOBEL. Quelques aspects radiologiques de la syphilis pulmonaire. (Certain roentgenologic aspects of pulmonary syphilis.) *Bull. et mém. Soc. de radiol. méd. de France*, June, 1931, *19*, 250–253.

The specific characters of pulmonary syphilis often lack individuality. Clinically as well as anatomically and roentgenologically syphilis is often confused with tuberculosis, tumors, bronchiectasis and other conditions occurring within the chest.

The authors present several cases of pulmonary syphilis showing some very unusual roentgenologic aspects. Thus in one of the cases the presence of multiple rounded shadows in the roentgen film of the chest together with a filling defect in the prepyloric region of the stomach suggested the diagnosis of gastric neoplasm with metastases to the lungs. The relatively good general condition of the patient, the positive Wassermann reaction, and the long duration of the disease finally directed the attention toward the right diagnosis of syphilis, which later was confirmed at post mortem. It is interesting that the institution of antiluetic treatment, although it brought about the complete disappearance of the filling defect of the stom-

ach, failed to influence the pulmonary lesions to any appreciable extent, the nodules maintaining their size unchanged for a period of over two years.

In the second case the appearance was that of a miliary tuberculosis, but here again the relatively good general condition, as well as the positive Wassermann reaction and the comparatively long duration of the disease, suggested pulmonary syphilis. In this case the institution of antiluetic treatment likewise failed to influence the aspect of the lesions of the chest.

In a third case sclerosis was the predominating change producing opacity of the entire left hemithorax with peribronchial retraction. The authors found that in such instances the contracting syphilis often led to multiple complications, as for example, bronchiectasis, pleuritis, encysted effusions, pachypleuritis, etc. In order to arrive at a correct diagnosis a repetition of the examination at various intervals and with various techniques was necessary.

Finally, in a fourth case there was unilateral opacity of one apex associated with aortic ectasia. There can be no doubt that the opacity of the lung was the result of sclerosis.

In summarizing the subject, the authors emphasize the fact that sclerosis is the predominating factor in most forms of pulmonary syphilis, cicatricial deformities nearly always being associated with the active lesions as demonstrated on the roentgenograms.—*T. Leucutia.*

McIntyre, Mary C. Pulmonary syphilis; its frequency, pathology and roentgenologic appearance. *Arch. Path.*, Feb., 1931, *11*, 258–280.

This article is a review of the literature on pulmonary syphilis and the opinions expressed are those of the workers whose papers are reviewed. The first portion consists of a historical résumé of the literature to date, then follows a discussion of the age and sex incidence, the white lung of the new-born infant, and various classifications of lung syphilis. The location of the lesions and the pathology are covered in a comprehensive manner.

Of greatest concern to the roentgenologist is the roentgen diagnosis of pulmonary syphilis. The cases reported soon after the introduction of the roentgen ray are stated in sequence. In the description of the roentgen findings the author states that the roentgen rays establish a point of contact between the clinical observations and the results at autopsy. The shadows seen in the roentgenogram may be due to fibrosis sufficient to arrest the rays. This fibrosis may be in the bronchi, blood vessels or interstitial tissue of the three sites. The bronchial situation is the most common.

When cardiovascular syphilis already exists and questionable shadows are seen by means of the roentgen rays the question arises: Do these shadows represent bronchial fibrosis or fibrosis of the pulmonary artery? In the latter event another question then presents itself: Are these shadows due to syphilis of the blood vessels since it has been stated that syphilis respects the integrity of these structures? It has been said that when cardiac syphilis exists, primary syphilis of the lung is ruled out as a cause of the shadows seen.

In cases of proved pulmonary syphilis, fibrosis in the roentgenogram shows as fibrous tracts more or less serrated. These tracts radiate from the point where the main lesion is located. Large cicatricial tracts cast polycyclic shadows. The arborescent tracts are fan-like and can be traced to their alternate ramifications. Between these tracts are shadows due to perilobular and interlobular fibrosis. Roentgenologically fibrosis in syphilis cannot be distinguished from that in tuberculosis, except that sclerosis localized at the hilus, calcification or cavity, point to tuberculosis, and peribronchial sclerosis with formation of rings points to syphilis.

The parenchymal shadows remain more or less circumscribed and are secondary to the sharply defined arborescent tracts. Enlargement of the mediastinal nodes or calcified nodes and annular shadows may be seen just below the hilus. These rings are probably due to fibrosis around bronchi and that portion of the bronchial tree near the median line and may occur in groups of three or four. Following the oblique direction of bronchi, one may find black, half circles of a more or less elliptical shadow devoid of lumen. Arborescent tracts, diffuse fibrosis, radiating in all directions from and along bronchi even to their termination, more or less marked emphysema and an enlargement about the hilus, are some of the aspects of pulmonary syphilis. It is not impossible that a secondary disease may be acting in a field already affected by syphilis. But in these cases there is usually an extreme production of fibrous tracts. In some cases calcified nodules

or enlarged nodes may be seen extending from the mediastinum to the cervical region in an uninterrupted chain.

When the exuberant fibrous tracts join apical shadows, causing a more or less homogeneous opacity, one should consider that a fibrous tuberculosis is grafted on a syphilitic terrain and look for parahilar shadows and calcified nodules.

Shadows due to carcinoma will give sharp margins, while syphilis has irregular borders. Pneumoconiosis resembles syphilis and tuberculosis combined. No roentgenologic differentiation can be made between pulmonary syphilis and unresolved pneumonia. No definite points of differentiation of pulmonary syphilis from other pulmonary conditions can be given with the exception of the radiating, fan-like lines seen in roentgenograms, located usually in the lower lobe, more often in the right side than in the left.—*R. S. Bromer.*

EGAS MONIZ, LOPO DE CARVALHO, and ALMEIDA LIMA. Angiopneumographie. (Angiopneumography.) *Presse méd.*, July 4, 1931, *39*, 996–999.

For some time, the authors have attempted to obtain a roentgen visibility of the pulmonary arteries and veins (angiopneumography). The experiments were first carried out on animals (rabbits, dogs and monkeys) by injecting a 40 to 80 per cent solution of sodium iodide directly into the right ventricle. Later, the opaque substance was injected into humans, starting with a concentration of 25 per cent and gradually increasing it to 60 per cent. The site of injection varied greatly: first the vein of the arm on one side, then on both sides simultaneously, then the gross veins of the neck were tried, only to find that the opaque substance had become diffused by the blood stream before it could reach the pulmonary vessels. Taken as a whole, the experiments in the human remained unsuccessful from the point of view of angiopneumography, but they led to some interesting observations concerning the physiology of the blood circulation of the neck. Thus it was found that there is a balancing effect between the deep and superficial jugular system, the latter retarding the speed of the blood stream in the subclavian vein to insure a better drainage of the blood from the deep jugulars into the vena cava superior, especially when the rush of the blood to the brain and head (through the carotid arteries) is too great.

In a second series of experiments, the authors tried, again first in animals and then in humans, to inject the opaque substance into the right auricle by means of a sound. For this purpose, they made a small incision on the vein of the arm using a procedure similar to that for intravenous injections, and introduced through the vein an opaque ureteral sound (70 cm. in length), the olive end of which had been cut off, into the right auricle. This manipulation, which was done under fluoroscopic control with the patient in the sitting position, as a rule was more successful on the left side than on the right. The only obstacle was encountered in the region of the external part of the subclavian vein, where the sound had a tendency to enter the external jugular vein. This was overcome by raising the patient's hand and by occasionally applying pressure with the fingers over the clavicular region during the passage of the sound through that portion of the vein. Care had to be taken also not to push the end of the sound beyond the right auricle, inasmuch as this was apt to enter the inferior vena cava rather than the right ventricle. When assured that the sound was in its proper position in the right auricle, the injection of the opaque substance was made as quickly as possible and a roentgenogram taken. For the purpose of the injection, the authors used two syringes which were adapted to the outer end of the sound, one 2 c.c. in size for physiologic serum and the other 10 c.c. in size for the opaque solution (an aqueous solution of chemically pure sodium iodide in an 80 to 100 per cent concentration). The physiologic serum was injected first, then after changing the syringes, 5 to 6 c.c. of the opaque solution. The roentgenograms were made during the injection of the last 1 or 2 c.c. of the opaque medium. Before withdrawing the sound the 2 c.c. syringe was readapted and again physiologic serum injected to wash out the remaining sodium iodide.

More recently the authors have substituted a specially constructed cardiac sound for the ureteral sound, which somewhat simplifies the technique of injection.

The roentgenograms of the chest revealed a very pronounced increase in the vascular markings as compared with those without injection. It is probable that a more concentrated solution of the sodium iodide or other opaque sub-

stances will further aid in the improvement of the procedure. So far, the method has been tried only in the normal and therefore nothing can be said as to its diagnostic value in pathologic cases. No untoward effects were observed except for a slight sensation of heat with occasional cough during the time of injection. It is suggested that the procedure may also prove of therapeutic value in certain well-selected cases.—*T. Leucutia.*

ABDOMEN

Gutman, René A., and Nemours-Auguste. Un procédé simple d'étude des plis de la muqueuse gastrique. (A simple procedure for studying the folds of the gastric mucosa.) *Bull. et mém. Soc. de radiol. méd. de France*, July, 1931, *19*, 326–327; also *Presse méd.*, Nov. 7, 1931, *39*, 1621–1623.

Various procedures were described for the demonstration of the folds of the gastric mucosa nearly all of them carrying considerable difficulties in their practical applications. The authors recently introduced a very simple method. They mix a spoonful of gelobarium with the yolks of two eggs and after administering this to the patient, they let him lie in every position (both sides, abdomen and back) for a few minutes to obtain a uniform coating of the stomach. The films are then taken in ventral decubitus. The advantage of such a procedure is that it permits the study of the folds of the stomach as well as of the duodenal bulb and that there is no deformity of the folds produced by the pressure as applied in other methods.

In conclusion, the opinion is expressed that despite the simplicity of the method it should be used only in well-selected cases as, for example, early carcinoma, study of the extension of the carcinoma, differentiation of an ulcer, etc.—*T. Leucutia.*

Hayer, E. Die Darstellung des Magenreliefs in Rückenlage. (The visualization of the gastric relief in the supine position.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, July, 1931, *44*, 70–77.

The following method, from Holzknecht's school, has been used for a number of years: after the first swallow of barium in the erect position the stomach is extensively palpated during deep inspiration. The patient is then placed in the supine position on the trochoscope and films taken without any compression. Several of these films are reproduced and discussed in the light of case reports to prove the value of the method.—*T. Leucutia.*

Imbert, René. Linite et calcification gastrique. (Linitis and gastric calcification.) *Bull. et mém. Soc. de radiol. méd. de France*, July, 1931, *19*, 351–352.

The author presents a case of complete calcification of the stomach with the walls from 1.5 to 2 cm. thick. The roentgen appearance was that of a porcelain stomach with loss of contraction and rigidity. A diagnosis of syphilitic linitis plastica was made in spite of a negative blood Wassermann.—*T. Leucutia.*

Gröninger, J. Zur Röntgensymptomatologie des operierten Magens. (The roentgen symptomatology of the operated stomach.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Sept., 1931, *44*, 302–319.

The study is based on a material of 108 cases, 30 of which were gastrostomies, 18 resections according to Billroth I, 49 resections according to Billroth II, and 11 other types of operations.

The technique of procedure included the examination both in thin layer and after full filling of the stomach. For the first the graded compression was used when studying the anastomosis itself and the mucosal folds of the stomach, whereas for the mucosal relief in the vicinity of the anastomosis as well as for the loops, examination in thin layer without compression proved of greater value. The second, that is, the examination with full filling of the stomach, was found to be of advantage in demonstrating the changes of the wall (niche, site of suture, perigastritis), of the size and position of the stomach and of the motor phenomena. Because of possible adhesions to the transverse colon a filling of this organ is also advisable.

It was found that a more or less typical roentgen appearance is encountered in the above-mentioned operations. The various types are described in detail. As a whole, the mucosal relief showed the greatest variation, the changes in the region of the anastomosis or at the place of resection being of particular importance. In one-fourth of the cases a fluid level was demonstrated. As to the peristalsis, it was noted that the less of the musculature of the lower portion of the stomach removed, the more this approached its normal type. The emptying of the stomach through the anastomotic stoma followed according to a regular rhythm. Only

2 cases of postoperative disturbances of the barium passage were observed by the author, both being described in detail.

In studying the roentgen demonstrability of recurrences within the operated stomach it was found that this is not always easy to accomplish. For example, in ulcer the changed mucosal relief and the more or less irregular serrated borders of the gastric outline often made the visualization of a niche impossible. In carcinomas, the author never found signs of a local recurrence although in 8 cases (out of 14) there was evidence of form changes due to extension in the surrounding tissues (6 of these cases were controlled at autopsy).

The most difficult problem from the diagnostic standpoint was the demonstration of a jejunal ulcer in the region of the anastomotic loops. Here the association of the direct sign (niche) with indirect symptoms (enlargement of the efferent loop, sensitiveness to pressure, incisure of the greater curvature opposite the anastomosis) was of the utmost importance.

In conclusion, the author emphasizes the necessity of the coordination of the clinical and roentgen findings, a preliminary knowledge of the type of operation performed being of great aid.—*T. Leucutia.*

Oppenheimer, Albert. Die Röntgenzeichen der sogenannten chronischen Appendizitis. (The roentgen signs of so-called chronic appendicitis.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Nov., 1931, *44*, 600–615.

1. The method of examination consisted in the oral administration of the Berg contrast mixture and study of the entire gastrointestinal tract. In case of non-filling of the appendix the examination was repeated after administering castor oil six hours p.c.

The signs were divided into local and distant, the latter being subdivided into adhesions and reflectoric changes.

2. In studying the local signs it was found that the fixation and kinking of the appendix were of clinical importance only when associated with disturbed function (disturbed filling, emptying and peristalsis), and especially with the demonstration of the classical point of tenderness. A non-filling, despite the administration of castor oil, with sensitiveness in the cecal region was indicative of an inflammation. In studying the functional disturbances one must bear in mind that a disturbed emptying of the appendix may also be observed in various constipations, especially in those associated with typhlatony.

3. Of the distant signs, the anatomic adhesions in the perityphlitic region were of great importance. When the adhesions involved the site of the appendix this latter was usually found at the posterior-medial or less frequently at the lateral aspect of the cecum, often leading to the characteristic picture of snail-shaped inversion of the cecum, with secondary stasis and pain starting, as a rule, twenty hours p.c. (when the emptying of the cecum commenced). When the transverse colon was also involved in the process the pain often assumed a colicky nature but when the adhesions extended to the sigmoid the symptoms were considerably less although sometimes very grotesque morphologic pictures were encountered.

4. The reflectoric symptoms manifested themselves chiefly in the form of pylorospasm or irritation of the duodenum or finally in spastic contractions of various protions of the colon. The reflux of the barium through the ileocecal valve was also thought to be of a reflex origin.

5. The conclusion is reached that so-called "chronic appendicitis" does not represent a clinical and pathologic entity. The gastrointestinal symptoms may be provoked by primary or secondary changes of appendicial origin. It would seem wiser to include under "chronic appendicitis" all those manifestations which occur as a result of an inflammatory infiltration or cicatricial adhesions in the appendix region. It is therefore the author's contention that the simple demonstration of deformities and fixation of the appendix does not necessarily indicate a disease of the appendix proper justifying a diagnosis of "chronic appendicitis," but that the objective findings, pain on pressure, etc., must be associated with functional disturbances of the digestive tract.—*T. Leucutia.*

Schmidtlein, Ernst. Über die aktive Beweglichkeit und den Entleerungs-mechanismus des Wurmfortsatzes. (On the active mobility and the mechanism of evacuation of the appendix.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Aug., 1931, *44*, 141–162.

The author studied the motor phenomena of the barium-filled appendix following injection of atropine and pilocarpine which as is known have the best antagonistic action on the para-

sympatheticus. The series examined included 21 cases. The usual citobarium mixture (2 tablespoonfuls in 150 c.c. water) was used as opaque medium, a filling of the appendix occurring seven to nine hours p.c. The technique of procedure was as follows: (1) a roentgen film was taken of the barium-filled appendix; (2) 0.01 gm. pilocarpine was injected intravenously and a second film taken within one to ten minutes; (3) a third film was made within five to twenty minutes following the second film, and (4) 1 to 2 mg. atropine was injected intravenously and the fourth film taken within four to fifteen minutes following the injection. The study comprised an analysis of the changes in position, form and shape of the barium-filled appendix. A brief résumé of the findings in all 21 cases is included in the text, numerous roentgenograms and schematic drawings being used for illustration.

The conclusions are reached that the motor phenomena of the appendix depend chiefly on the tonus of the muscular layer. The proximal antral portion of the appendix shows, in addition to this, peristaltic and spastic changes, whereas the distal portion appears quite sluggish. The increased tonus is evidenced by a shortening (up to two-thirds) of the appendix shadow with widening of the lumen and straightening of the tortuosities or kinkings. As a rule only the proximal third or half of the appendix empties, the sluggish distal portion nearly always forming the site of stasis. The relaxation of the muscular tonus leads to elongation of the appendix with segmentation of the opaque contents. The peristalsis is characterized by irregular contractions and only occasionally by alternating movements along the longitudinal axis. It leads to fragmentation of the appendicial content with forceful evacuation. A local spasm around the antrum results in disturbance of emptying or filling of the appendix.—*T. Leucutia.*

Piot, Etienne, and Picarda, J. Contribution radiologique au diagnostic de l'appendicite et de la périviscérite iléo-caecale. (Roentgen contribution to the diagnosis of appendicitis and ileocecal perivisceritis.) *Presse méd.*, Nov. 7, 1931, *39*, 1633–1637.

The authors, after describing their technique of procedure in roentgen examination of the gastrointestinal tract, discuss in detail the roentgen symptomatology of appendicitis and ileocecal perivisceritis. They conclude that the demonstration of pain localized to the region of the appendix (by examining the patient in various positions) is the surest sign of appendicitis, the other signs, as for example stasis, ileocecal spasm, filling of the appendix, etc., being of only secondary importance. The roentgen diagnosis of perivisceritis must still remain uncertain. In some cases the symptoms of colitis dominate the picture, there being no evidence of adhesions, while in others the adhesions may remain undetected until more advanced disorders are produced. It is not unusual to see that the surgeon, in spite of a most minute roentgen examination, finds himself at operation confronted with lesions considerably more advanced than those demonstrated by the roentgen ray.—*T. Leucutia.*

SKELETAL SYSTEM

Schmorl, G. Anatomische Befunde bei einem Falle von Osteopoikilie. (Anatomic findings in a case of osteopoikilosis.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, July, 1931, *44*, 1–8.

Recently several communications have appeared in the literature describing individual cases of a skeletal anomaly, so-called osteopoikilosis. Albers-Schönberg was the first to report the roentgen findings in such a case, but the name "osteopoecilie" originates from the French authors who used it to express the "spotted" character of the disease. The condition consists of numerous areas of increased density of pin-head to lentil size scattered in the spongiosa of all bones except the skull and the spine. The epiphyses and the short bones of the hands and feet form the seat of predilection. In 1930, Kahlstorf (*Röntgenpraxis*, 1930) collected and tabulated all cases from the literature. Since then Awalischwili has added another case (*Röntgenpraxis*, 1930). However, in none of these could an anatomic investigation be made.

The author was able to examine a case which eventually came to autopsy and he wishes to report the anatomic findings. The case is that of a student fourteen years of age who was first examined in January, 1927, for acute osteomyelitis of the right tibia. During the examination, it was found that he also had osteopoikilosis. Later he developed several contractures, ankyloses, etc., and in October, 1929, he died as the result of a generalization of the osteomyelitis (marasmus, amyloidosis, severe secondary

anemia). Serial microscopic examinations of the "spotted" areas revealed that the increased density was the result of numerous bone trabeculae of various thicknesses arranged rather regularly, the bone resembling the structure of the spongiosa and not of the cortex. The individual trabeculae were slightly thicker than those of the normal bone in that particular region. Because of this, and their close arrangement, they gave the impression of a compact bone. The merging into the surrounding structures was gradual, the trabeculae disappearing among those of the normal spongiosa. The thicker trabeculae consisted of lamellous bone arranged mostly parallelly but in a few instances also concentrically around blood vessels, however without leading to the picture of typical osteoma.

No deductions can be made from the above microscopic findings concerning the genesis of the disease. An endochondral origin can be eliminated on the basis that the foci show no connection with the endochondral zone of growth. The most plausible theory is that of a congenital anlage. It may be of added interest that the spots within the osteoporotic ankylosed areas themselves showed signs of osteoporosis, indicating that they led to vita propria as is the case in some congenital malformations.—*T. Leucutia.*

LYON, ERNST, and MARUM, GOTTLIEB. Krankheiten der Wirbelkörperepiphysen. (Diseases of the epiphyses of the vertebral body.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Oct., 1931, *44*, 498–507.

The investigations of the anatomy and development of the epiphyses of the vertebral body have led more recently to some rather heated discussions on a number of problems such as "epiphysitis," "persisting epiphyses of the vertebral bodies," "kyphosis dorsalis adolescentium," etc. It is the authors' contention that the condition called "epiphysitis" is not the result of inflammation or tuberculosis, but of other causes such as developmental changes, disturbances of the epiphyses of the vertebral body, etc. The same applies to the "persisting epiphyses of the vertebral bodies." Junghanns, for example, could not find one single such case in the large bone material of Schmorl, this indicating that the condition is exceedingly rare or that it does not occur at all. The triangular shadows observed in the lateral view at the upper and lower borders of the vertebral bodies may represent simple bony fragments from trauma, or calcifications in the anterior longitudinal ligament. "Kyphosis dorsalis adolescentium," which by many is likewise considered as a primary disease of the epiphyses of the vertebral body, is according to Schmorl the result of primary changes of the intervertebral discs. The possible occurrence of injuries, osteomyelitis and tuberculosis in the epiphyseal region still further complicates the problem, making a differentiation in many instances impossible.—*T. Leucutia.*

JANKER, ROBERT. Persistierende Apophysen der Wirbelsaule. (Persisting apophyses of the vertebral column.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Oct., 1931, *44*, 519–522.

The author in a former article (see this Journal, 1930, *24*, 592–593) described several cases of persisting epiphyses of the vertebral bodies. Since then a few articles have appeared in the literature denying the existence of such a condition. The most important among these is the article of Junghanns in which he states that in the large bone material of Schmorl (3,500 cases) he could not find one single case. Junghanns also makes the statement that the triangular shadows described as persisting epiphyses of the vertebral bodies most probably represent bony fragments or calcifications within the intervertebral discs. The author after re-examining his material contends as before that the condition exists. The multiplicity of the lesion and the absence of injury would speak against a traumatic basis, while the fact that the triangular shadow is placed with its longest (and not shortest) side against the surface of the vertebral body would rule out a calcification in the disc. The author is of the opinion that the reason why Junghanns did not find any cases of "persisting epiphyses of the vertebral body" in the large collection of Schmorl, whereas the author is his 1250 to 1400 cases has found several, is due to the fact that not all of Schmorl's cases were roentgenographed in the lateral view.—*T. Leucutia.*

BÖHMIG, R. and PRÉVÔT, R. Vergleichende Untersuchungen zur Pathologie und Röntgenologie der Wirbelsäule. (Comparative examinations on the pathology and roentgenology of the spinal column.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, May, 1931, *43*, 541–575.

The authors made comparative roentgen-

ologic and pathologic studies of specimens of the spinal column in 65 cases. The following noteworthy changes were found:

A. Intervertebral discs. (1) Ruptures and bleedings. These occurred in 28.8 per cent, the lumbar portion of the spine forming the site of predilection. It is most probable that they were the result of a traumatic pull of the ligamentum longitudinale posterior on the intervertebral disc during maximum ventral flexion and not of degenerative disturbances. They represented the first phase in the changes of the intervertebral disc. (2) Fissures. These were sequels of degenerative processes occurring chiefly in advanced age. It must be mentioned, however, that in the material examined they did not extend to the upper and lower cartilage plates, indicating that senile atrophic disturbances of the disc may occur without involvement of the adjacent cartilages. Neither the ruptures, nor the bleedings nor the fissures as described in (1) and (2) were visualized in the roentgenograms. (3) Ossification. In the study of this process the roentgen procedure was of considerably greater aid than the macroscopic examination. The ossifications appeared, as a rule, circumscribed and they were associated either with osteophytic changes of the vertebral bodies or with marked narrowing of the intervertebral discs. They occurred only following injury to the cartilage plates or the adjacent enclosing bony plates. (4) Cartilage nodules. A total of 211 cartilage nodules were observed in the material examined but of these only 37 per cent were visualized in the roentgenograms. In this respect the pathologic examinations, as well as certain experimental investigations, revealed that neither the extent of the destruction of the hyaline cartilage plates or of the adjacent bony plate, nor the size of the cartilage nodules, had any influence on the roentgen visibility. The presence or absence of bone new formation at the borders of the cartilage nodule and the concomitant displacement of the traumatized bony plate were the only factors concerned.

B. Vertebral bodies. (1) Epiphyses. (*a*) Normal and variations. Nothing new is added as regards the roentgen appearance of the normal epiphyses and their morphologic variations. (*b*) Fractures in adults. Three types of fractures were differentiated in the epiphyses of adults, all showing plainly in the roentgenograms. In the first type the fracture involved the ventral or lateral surface of the vertebral body and because of its association with a marked atrophy of the spongiosa and narrowing of the intervertebral space, nearly always led to lipping of the upper or lower vertebral borders. In the second, the fracture occurred at the site of the union of the rim band with the cartilage plate, producing a hook-shaped deformity of the inner border of the rim band with penetration into the spongiosa. The third type was characterized by the so-called splinter-fracture of the rim band as described by Schmorl. In all types the marked atrophy of the vertebral body and osteoporosis of the spongiosa were the provoking factors, the degeneration of the discs being of only secondary importance. (2) Spongiosa thickenings. (*a*) Without the association of cartilage nodes. Here again three forms were differentiated. In the first, the thickenings extended only to the bony plates of the vertebral bodies; in the second, which occurred chiefly in the young, they led to parallel bony plates within the spongiosa of one of the adjacent vertebrae and in the third, which occurred chiefly in advanced age, they led to parallel bony plates in the spongiosa of both adjacent vertebrae. The authors insist emphatically upon the separation of these two latter forms inasmuch as they represent distinct processes, an association of the two never having been observed in the same individual. (*b*) With the association of cartilage nodes. The various forms of thickening of the spongiosa occurring in connection with and in the vicinity of the cartilage nodes were previously described by Schmorl, Putschar and Brack. Generally, the formation of the thickened layers conformed to the extent of the defect of the hyaline cartilage and bony plates and to the degree of pressure within the disc which in turn depended on the structural changes. (3) Metastases. These led to either osteoblastic or osteoclastic processes, offering no difficulty in diagnosis.

A bibliography on the subject is appended.—*T. Leucutia.*

Dausset. Sur un nouveau cas de nucléus pulposus calcifié. (A new case of calcified nucleus pulposus.) *Bull. et mém. Soc. de radiol. méd. de France*, May, 1931, *19*, 232–235.

A calcification of the nucleus pulposus between the 11th and 12th dorsal vertebrae occurring in a man fifty-three years of age is briefly described. It represents the fifteenth case published in the literature. The only pathologic manifestation was pain, which entirely disap-

peared following immobilization. It is probable that a permanent corset support will be required.—*T. Leucutia.*

WAGONER, GEORGE, and COHEN, BERNARD N. E. Osteochondritis dissecans; a résumé of the theories of etiology and the consideration of heredity as an etiologic factor. *Arch. Surg.*, July, 1931, *23*, 1–25.

Osteochondritis, as defined by Wagoner and Cohen, is a noninfectious process involving the articular cartilage and the subchondral bone of certain long bones of the extremities, which, by sequestration from the articular surface, usually produces a single foreign body or, more rarely, two, in the contiguous joint. This body is originally of an osseocartilaginous composition, but its structure subsequently undergoes alteration by the fluids in the joints. The common sites of occurrence are the mesial half of the articular surface of the internal femoral condyle, less frequently, the heads of the radius, femur and humerus. Osteochondritis dissecans occurs preëminently in youth, and most commonly in the tall rapidly growing boy.

Free bodies within the joints may be encountered in conditions other than osteochondritis dissecans. All such bodies are grouped under the common head of corpora libera articulorum or "joint mice." Some of these conditions are: free bodies of traumatic origin; free bodies in joints that are affected by arthritis deformans; polypoid bodies present in the hypertrophic type of arthropathic tabetique; masses of uric acid salts found free within gouty joints; osteomyelitic sequestra occasionally found within a joint; parts of tumors of the capsule in chondromatosis of a joint; fibrous or lipomatous joint papillae; parts of hypertrophic synovial villi following a synovitis severed from their base by trauma or necrosis; corpora oryzoidea (rice bodies); fibrin formation following hemorrhage or inflammation in a joint; foreign bodies from external sources.

From their study of the literature the authors state that the theories of etiology of the condition are grouped into two large divisions: (1) papers in which trauma is set forth as the chief etiologic factor and (2) papers in which factors other than trauma are advanced as causative agents. They quote approximately fifty or more authors, giving a summary of the various theories of etiology.

Five cases are reported in detail with clinical, pathological and roentgenological findings. Their cases seemed to point to a definite hereditary etiological factor, and they conclude that heredity must be so considered. Of their 5 cases, 3 occurred in one family, son, father and paternal uncle; 2 in two brothers, in one of whom there was bilateral involvement. The involvement of more than one joint in the same person is uncommon. Comparatively few such cases have been reported.

A valuable feature of this paper is the complete bibliography, selected from 365 articles. With the exception of two papers which were not available to them, all of the articles were abstracted. They think these include the entire literature on the subject of osteochondritis dissecans.—*R. S. Bromer.*

SCHWENTKER, FRANCIS F. Cystic tuberculosis of the bone. *Am. J. Dis. Child.*, July, 1931, *42*, 102–106.

Schwentker's paper is noteworthy in that it calls attention to a form of multiple tuberculosis of the bone in which a cystic formation predominates, and which has been little described in American literature. In 1920, Jüngling described a cystic condition of the metatarsals, metacarpals, and phalanges, associated with lupus vulgaris, in the hands and feet of young adults. Occasionally the cuneiform, cuboid, ulna and nasal bones were affected. Although no definite proof was obtained at that time, he considered this syndrome to be tuberculous in origin and suggested the name "osteitis tuberculosa multiplex cystica." Since then additional cases have been reported, so that in 1928, Jüngling was able to collect reports of 46 cases to which he added 9 of his own.

Schwentker could find no report in the literature of a case of cystic tuberculosis of the bone occurring in infancy. He reports his case because it shows tuberculous processes in both the diaphyses and the epiphyses, and because under treatment, these lesions healed.

Clinically, tuberculous processes in the long bones of children may be divided into two groups according to location: (1) those in the diaphysis and (2) those in the diaphyso-epiphyseal region. In either case the primary factor is a lodgment of the tubercle bacilli in the interior of the bone. The type of lesion that results depends upon the individual reaction of each patient to the tubercle bacillus, but for the most part lesions are formed that are characteristic of each region. In the case of the diaphysis, the process is essentially the same as in the epi-

physo-diaphyseal region except that it is modified by periosteal reaction. Here there is central caseation with surrounding fibrosis, but the entire lesion is limited by the formation of new bone in the subperiosteal region, so that the process is apt to assume a spindle-shaped or piriform outline. Again, the caseous process may predominate with the subsequent formation of abscesses and sinuses, or more rarely, the lesion may be so completely limited as to form a stationary tumefaction, or it may even retrogress to a healed process. However, when caseation begins in a tuberculous lesion, whether in the bone or elsewhere, progression of the process is the rule, so that the formation of abscesses and sinuses is most apt to occur. This is especially true of osseous tuberculosis when the caseation begins early. For this reason the stationary or regressing lesion is uncommon, and this probably explains the paucity of reports of cases of cystic tuberculosis of the bone.—*R. S. Bromer.*

Neale, A. Victor, and Allen-Price, E. D. Chondrosarcoma of the fibula. *Brit. J. Surg.*, July, 1931, *19*, 47–51.

An apparently benign chondroma with some areas suggestive of malignancy of the fibula had been removed. Three years later the growth recurred, amputation was performed, and the pathologist reported an obvious chondrosarcoma with definite cell activity and invasive character. This case illustrates that sarcomatous changes in a chondroma may be very gradual and may remain within the bounds of cure by amputation for a moderate period of time.—*F. H. Decker.*

Seifert, E. Einige Fehlbildungen im Schultergelenk. (Some misformations in the shoulder joint.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, May, 1931, *43*, 620–624.

Three types of misformations occurring in the shoulder joint are described on the basis of 3 cases observed. These are: (1) humerus varus, in which the changes extended both to the humeral head and glenoid cavity; (2) congenital high position of the scapula which was associated with a maldevelopment of the humeral head, and (3) angulation of the upper end of the humerus (just underneath the epiphyseal line) which most probably was the result of injury at birth. The roentgenograms in the three cases are included for illustration.—*T. Leucutia.*

Behr, F. Uber familiäre Kurzfingrigkeit, Brachydaktylie, Klinodaktylie. (On familial shortening of the fingers, brachydactyly, clinodactyly.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Oct., 1931, *44*, 516–518.

Brachydactyly is a shortening of the fingers involving mostly the middle phalanges (also called brachymesophalangy). The author describes such a case occurring in father and son. The mother in the case had a slight degree of arachnodactyly of the hands and feet, with a supernumerary (third) phalanx of the fifth toe, and the same condition was observed in two other children.

Clinodactyly represents a form of brachyphalangy, the terminal phalanx of the small, ring and index fingers (in the order named) showing because of the bending of the middle phalanx a lateral deflexion (digitus varus or valgus). Such a case was observed by the author in father and two daughters, the degree, extent and order of involvement being identical.—*T. Leucutia.*

Duggan, LeRoy B., and Bromberg, Leon. Syphilis of bone resembling osteitis deformans. *Am. J. Syph.* Oct , 1931, *15*, 538–543.

The authors report a case of thickening of the skull by a diffuse osteitis and thickening of the tibiae by osteitis and periosteitis. Clinically and serologically the patient was syphilitic. They conclude from this, and from the fact that clinically there was no enlargement of the head, that the osteitis was due to syphilis, rather than to Paget's disease of the bones.—*M. T. Harris.*

Petrignani, Roger. Formes évolutives et formes stabilisées de la maladie de Pellegrini-Stieda. (Evolutive and stabilized forms of Pellegrini-Stieda's disease.) *Bull. et mém. Soc. de radiol. méd. de France*, June, 1931, *19*, 287–291.

In a previous article (see abstract, this Journal, July, 1931, *26*, 129–130) the author dealt at length with various aspects of Pellegrini-Stieda's disease. Among other things he emphasized the necessity: (1) of a systematic roentgen examination immediately following the injury in all cases of sprain of the knee; (2) of a repetition of the examination five to eight weeks later in order to establish if Pellegrini-Stieda's disease has developed, and (3) of repetition of the examination at intervals of from two to three months in case the presence of Pellegrini-Stieda's disease has been demonstrated in order

to find out whether the ossification is of the "evolutive" type or whether it has already become "stabilized."

In the evolutive cases, roentgen therapy is often of decided benefit bringing about a stabilization. Apart from the progress of the disease as demonstrated in the roentgenograms taken at various intervals, certain roentgen characteristics may also help to differentiate the two forms. Thus a hazy outline of the ossification with more or less fuzzy opacification of the adjacent connective tissue indicates that the lesion is still in evolution, whereas the visualization of a well-defined sharp outline with a good definition of the adjacent structures proves that the process has already become stabilized. —*T. Leucutia.*

GAVRILESCU, STELIAN G. Osificare paracondiliană internă a femurului metatraumatică. Boala lui Pellegrini-Stieda. (Metatraumatic internal paracondyloid ossification of the femur. Pellegrini-Stieda's disease.) *Cluj. med.* Oct., 1931, *12*, 534–537.

Although more recently there is a tendency to include Pellegrini-Stieda's disease among metatraumatic ossification processes, whether they be of the articular capsule, ligaments or serous bursae, the author still prefers to use the original classification.

At the University of Cluj only 2 cases of Pellegrini-Stieda's disease have been observed during the past ten years, indicating that the condition is quite rare. In both cases, there was definite evidence of trauma, the chief clinical symptoms consisting in pain and impaired function of the extremity affected (5–20 per cent disability). The roentgenograms revealed a semilunar-shaped ossification at the inner aspect of the femoral condyle such as is usually observed. In one of the cases, the ossification was removed surgically with very marked clinical improvement. The microscopic report revealed that the bone trabeculae were the result of both cartilaginous and fibrous osteogenetic processes.

In considering the roentgen diagnosis, the author advises (1) that roentgenograms be taken immediately following the accident, (2) that the examination be repeated at definite intervals for a study of the evolution of the process, (3) that the examination be made bilaterally and (4) that roentgenograms be taken at the time of testimony should the case assume a medicolegal aspect.—*T. Leucutia.*

POLITZER, G. Uber Missbildungen des Hand- und Fussskelettes und über ihre formale Genese. (On malformations of the hand and foot skeleton and their formal genesis.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, May, 1931, *43*, 605–619.

The author describes 14 cases of malformations of the hands and feet, consisting chiefly of numerical and morphologic variations. Several roentgenograms and drawings are included for illustration. After a study of the changes in form, the genesis is explained on the basis of an embryonic maldevelopment. Amniotic twists or abnormal under-development of the amnion apparently do not enter the process.—*T. Leucutia.*

HARMON, PAUL H., and MCKENNA, HUGH. Primary myelogenous sarcoma complicating cystic disease of the humerus. *Arch. Surg.*, June, 1931, *22*, 903–925.

Primary tumors of the bone, as stated in the opening paragraph of this paper, characterized by an unorganized growth of round cells, without appreciable intercellular substance, occupy an uncertain position among malignant neoplasms of bone. In the literature, one may find such varied designations of these tumors as "solitary myelomas," "undifferentiated osteogenic sarcomas," "round cell sarcomas of bone," "endotheliomas," "cellular medullary tumors," "embryonal tumors of bone marrow" and "myelosarcoma." Ewing's sarcoma, apparently a homogeneous clinical entity, has but recently been segregated from this ill-defined category of tumors.

The authors report a case of a confusing tumor of the humerus which they think clearly originated as a complication of preëxisting cystic disease of the same locality. This tumor had microscopic characters in common with the group of myelomas, while a disseminated, scanty, fibrous, hyaline and osteoid intercellular substance and certain of its gross characteristics allied it to the osteogenic sarcomas.

Cystic disease of the bone is believed rarely or never to undergo malignant change into primary sarcoma of bone. Instances of solitary primary malignant tumors of bone composed exclusively of cellular elements resembling the round cells of normal bone marrow are rare. Thus Kolodny states that only one case of solitary myeloma has been reported in the Registry of Bone Sarcoma of the American College of

Surgeons. Undifferentiated osteogenic sarcomas, tumors that microscopically are composed of round cells which show no tendency to form any known structure or tissue, are uncertain in their right to belong to this class of tumors (Codman).

The case reported is that of a female, aged sixty-eight, who was admitted to the hospital for a fracture of the left humerus. This had resulted after a light fall over a rug in her house. The roentgenogram showed cystic disease, a large circumscribed area of rarefaction with the large axis parallel with the long axis of the shaft which left only a thin shell of cortex in the distal part of the bone. Subsequently she suffered two more fractures at intervals in the same area. The last occurred nine months after the first. At this time the roentgenogram showed in addition to the cystic changes, erosion and apparent invasion with periosteal lipping, very suggestive of malignancy. This was confirmed at operation. The definite change in her symptoms which occurred a few days after the third pathologic fracture, the authors regard as especially significant, inasmuch as they suspect this as the symptomatic onset of sarcoma. They regard the evidence that a benign cystic condition first existed as definite. By roentgenographic evidence obtained from the various examinations, they place the actual onset of the malignant change a few weeks prior to the second fracture.

On the positive evidence of bony periosteal lipping and the presence of a significant although small amount of stroma that could have been produced by potential osteoblasts, a diagnosis of an osteolytic myelogenous sarcoma was made. The age of the patient and the location in the distal metaphysis of the humerus are qualities rarely associated with this type of neoplasm.

The majority of microscopic fields of sections of the tumor demonstrated a picture not inconsistent with myeloma and the authors regard this as an illustration of the deceptiveness of incomplete histologic study of a malignant tumor of bone.—*R. S. Bromer.*

BLOOD AND LYMPH SYSTEM

Sgalitzer, M., Kollert, V., and Demel, R. Kontrastdarstellung der Venen im Rontgenbilde. (Visualization of the veins in the roentgenogram by means of a contrast medium.) *Klin. Wchnschr.*, 1931, *10*, 1959.

During an intravenous injection of uroselectan or abrodil one can study the circulation in the veins of the extremities on the fluoroscopic screen. It is possible to differentiate also a functioning from an incompetent valve in the blood vessel. The lumen of the veins can vary between narrow and side; the narrowing may even under normal conditions lead to a temporary reversal of the blood stream. The varicose vein shows a very characteristic roentgen picture. It is stretched both in width as in length and the valves are incompetent. Muscle contractions expel the blood from the diseased veins but they do not show the fluctuations of the lumen as normal veins do. The veins in the neighborhood of a gastric ulcer show also a very characteristic arrangement. A number of hemangioma were studied following injection of the contrast medium and it is suggested to treat these lesions by injection of hypertonic glucose solution.—*E. A. Pohle.*

GENERAL

Brailsford, James F. Hydatid disease in England. *Brit. M. J.*, Jan. 24, 1931, *1*, 133–136.

Hydatid disease is not rare in England, although less frequent than in Iceland and in the countries with extensive sheep farming, as Australia and the Argentine.

The life cycle of the parasite and mode of animal and human infestation are comprehensively discussed. These are interesting but the clinical features and roentgenological manifestations are of most importance. The site is as follows: liver, 70 per cent; lungs, 10 per cent; kidneys, 2.5 per cent; spleen, 2.5 per cent; other abdominal organs, 5 per cent; muscles 5.0 per cent; brain, 5 per cent, and bones, 1 per cent. Pulmonary cysts rupture into the bronchus frequently with a cure occurring in 50 per cent of the cases. The disease causes symptoms due to pressure. In the liver the cyst may push up the diaphragm, compress or rupture into the biliary ducts, portal vein, duodenum, pleura, bronchus or peritoneal cavity. In the thorax, the cyst may displace the heart, great vessels, trachea, bronchi, or esophagus. It may produce erosion of the vertebrae or ribs adjoining the cyst. It may rupture into the heart, pericardium, bronchus, esophagus, vena cava or pleura. In the skull, pressure symptoms, simulating those of tumor occur, and this is also true of cysts occurring in the spine. Cysts occur in bone which resemble the ordinary bone cyst. These are usually slow growing.

Diagnosis. A positive precipitation test occurs according to Dew, in about 65 per cent of hydatid patients. Intradermal injection of sterile hydatid fluid, as suggested by Casoni, gives a positive reaction in 90 to 95 per cent of the cases according to Dew. The hydatid cyst may exist for years without producing any specific symptoms, the first suggestion of this disease being obtained during roentgen examination. The features of the hydatid cyst of the lung depend upon the condition of the cyst. If it is a simple cyst and unruptured, it will appear usually as an ovoid shadow, uniform in density, with a well-defined margin, and without any changes in the surrounding lung tissue. If it has ruptured only the outline of the cyst may be shown, and it may be mistaken for a pleural ring. If it has ruptured and the cyst only partially evacuated a fluid line may be seen. Calcified cyst walls cast a dense shadow and this appearance is very suggestive. Cysts near the mediastinum or ribs must be differentiated from fibroma, sarcoma, dermoid cyst, encapsulated fluid, carcinoma, abscess and aneurysm. The contents of hydatid cysts is very irritating and rupture may induce a surrounding pulmonary or pleural reaction which cannot be differentiated from inflammatory conditions. Cysts in the abdomen can usually only be recognized when the wall contains calcification, giving the suggestive crescentic or circular shadows. Hydatid cysts have been demonstrated in the liver and spleen after pneumoperitoneum has been performed. Owing to the grave danger of rupture of the hydatid cyst of the brain into the ventricle, it is most unwise to perform ventriculography where this condition is suspected.—*J. H. Vastine.*

JAUBERT DE BEAUJEU, A., and BLOCH, E. Un cas de syndrome de Klippel-Feil. (A case of Klippel-Feil's syndrome.) *Acta radiol.*, Apr. 15, 1931, *12*, 140–145.

In 1912 Klippel and Feil described a syndrome characterized clinically by short neck, low hair line and limitation of the movements of the head on the trunk without pain. Anatomical and roentgen examination showed crowding together and apparent or real decrease in the cervical vetebrae, cervical thorax from hyperelevation of the thorax and almost always superior cervical spina bifida. Often the Klippel-Feil syndrome is accompanied by other pathological processes or malformations, such as torticollis, kyphoscoliosis, atrophy of various muscles, neurological and trophic disturbances, congenital anomalies of the limbs, heart lesions, mental weakness, deaf muteness, etc. Cases of the pure syndrome are rare.

The authors describe one in a girl aged seventeen with no family or personal history of any importance. She had always been well and had worked as a chambermaid. Recently her family had noticed that her head seemed buried between her shoulders and she had noted some difficulty in rotating her head. Examination showed some limitation of the lateral movements of the head; nothing abnormal in the heart or lungs. Roentgen examination showed that the atlas was followed by a block made up of the fused cervical vertebrae and another normal vertebra with costiform processes preceding the first dorsal. There was a superior dorsal spina bifida and a trace of cervical thorax. There was also a sacral spina bifida, but this is not unusual in normal cases. This therefore was a pure case of Klippel-Feil syndrome. Most authors consider these lesions congenital and some think that they are caused by syphilis.—*Audrey G. Morgan*

ROENTGEN AND RADIUM THERAPY

TALIA, FERDINANDO. Gozzo endotoracico con grave stenosi esofago-tracheale curato con i raggi X. (Intrathoracic goiter with severe stenosis of the esophagus and trachea cured by roentgen rays.) *Radiol. med.*, Apr., 1931, *18*, 476–486.

The patient was a woman of twenty-nine. In 1924 she had begun to have signs of thyroid dysfunction and early in 1927 enlargement of the right side of the thyroid developed, with slight dysphagia. This disappeared spontaneously but in 1928 a similar swelling appeared on the left side. Under medical treatment it disappeared almost completely. In November, 1928, two roentgen examinations of the neck and thorax were made with negative results. Each time the patient's dysphagia, suffocation and hoarseness improved greatly. In January, 1929, she grew worse again and had various symptoms of thyroid and ovarian dysfunction. In September, 1929, she had slight enlargement of the supraclavicular region on the left side and marked signs of hyperthyroidism. Roentgen irradiation was begun and in a few days she was so much better that she stopped the treatment. The improvement persisted for about

five months but in February, 1930, very serious disturbance began again and by June, 1930, she was in very serious condition with suffocation and great emaciation from inability to swallow. For five days before she came to the author for examination she had been unable to swallow even water. She had an irregular fever. Roentgen examination showed a retrotracheal intrathoracic goiter. The same day she was given a roentgen treatment with 180 kv., filter 0.5 mm. zinc and 2 mm. aluminum; the total depth dose was 20 per cent of a skin erythema dose. This dose was repeated once a week for five consecutive weeks. The patient's condition grew worse for two days after the first irradiation but then began to improve and she recovered entirely. Thirty diathermy treatments were given later for a peri-esophagitis with adhesions to neighboring organs. Successive roentgen examinations showed not only disappearance of the goiter but progressive decrease in the size of the greatly enlarged heart.—*Audrey G. Morgan.*

Holfelder, Hans. Örtliche Neben- und Nachwirkungen der Röntgenstrahlen. (Local by- and after-effects of roentgen rays.) *Strahlentherapie*, 1931, *41*, 27–38.

The author maintains that the expression "roentgen burn" should not be used to designate roentgen injury, for one of the therapeutic by-effects of irradiation is an erythema which may be confused in the lay mind with a burn, to the detriment of the roentgenologist. And the injury to the tissues caused by roentgen rays is not the same as that produced by heat. He therefore proposes using the terms inflammatory or caustic by-effects. Such injuries may take place not only immediately after the treatment but after many months or years. They have been very greatly reduced by improved technique but it is still not possible to prevent them entirely, particularly in deep therapy.

In judging injury, however, the fact must be taken into consideration that, in roentgen therapy as in surgery, it may be necessary to do some harm in order to accomplish a greater good. Though loss of an arm is a great mutilation, no one would blame a surgeon for amputating an arm for a sarcoma or an inflammation that threatened life and the same principle should be applied in roentgenology. A roentgenologist should not be blamed, for example, for using a dosage in inoperable cancer of the stomach that might later cause an ulcer of the abdominal wall. But the same injury would be blamable in a less serious condition. The by-effect must not be out of proportion to the severity of the disease treated. Every new field that is conquered requires some sacrifices, and injuries that were not blamable in the early period of roentgenology may now be considered culpable because with proper knowledge of the subject they are avoidable. There is no need now of causing caustic by-effects in roentgen examination for diagnostic purposes if the roentgenologist is master of his technique. The same is true of superficial therapeutic irradiation and of deep irradiation with small doses, but there are still some unavoidable injuries in deep irradiation with large doses.

The requirements for roentgenologists should therefore be as strict as for surgeons. Because the treatment is bloodless this fact has not been appreciated, but the time has come when there should be legal control of roentgen teaching and practice just as there is of medical and surgical.

In giving legal opinions on roentgen injuries, it is first necessary to determine that the injury really is caused by the rays and not, for example, by extension of a carcinoma or by a syphilitic ulcer. It may be due to a combination of roentgen irradiation and some exogenous factor. But that does not excuse the physician if he has used an excessive dose of radiation. In deep treatment, even if the proper individual dose is used, there may be injury from a cumulative action if the treatments are given too close together. It still remains to determine just what the proper interval is. Scientific opinion on this point has varied considerably in the past ten years and therefore considerable caution should be exercised. An examination for objective evidence of the cause of the injury should be made and no attempt made to explain it away as idiosyncrasy to roentgen rays. It is now quite generally agreed that there is no true idiosyncrasy to the rays and such a course only brings roentgenology into disrepute. Even if the doses and intervals prescribed have been correct, a careful technical examination must be made to see if the doses actually given were the ones prescribed.

The collection of cases of roentgen injury by Groedel, Liniger and Lossen furnishes a great deal of interesting material in this field. While they find that about a third of the cases are due to lack of proper knowledge on the part of the roentgenologist and about a third to lack of

skill on the part of the technician, the impression is given that it is not so much the physician who is to blame for these injuries as the law which allows inexperienced individuals to make use of such a serious method of treatment.—*Audrey G. Morgan.*

MELDOLESI, GASTONE. Diagnostica e terapia radiologica dei tumori ossei secondari ad epitelionia della mammella e dell'utero. (Roentgen diagnosis and treatment of bone metastases from epithelioma of the breast and uterus.) *Radiol. med.*, Sept., 1931, *18*, 1160–1183.

Twenty-six cases of bone metastasis from carcinoma of the breast and uterus are described. Twenty of them were secondary to tumors of the breast and 6 to tumors of the uterus. All of the patients had been operated on or irradiated before the bone metastasis developed. This brings up the question of whether such treatment tends to increase bone metastases. Apparently in recent years since almost all tumors of the uterus have been treated by surgery or radium there have been more bone metastasis but this may be merely due to the fact that the patients' lives are prolonged so that metastases have more time to develop.

In 19 of the above 26 cases the bone metastases were given roentgen treatment. One of them has been treated too recently for any judgment to be passed on the final result. Eight of the patients are still living, one of them almost four years after the treatment. Three others showed marked decrease in the bone tumors with new formation of osteosclerotic tissue but died later from other metastases, while 7 were not greatly improved. In all except 2 of the cases pain was alleviated and the general condition greatly improved by the treatment.

The technique varied depending on the severity of the lesions, the patient's general condition and the course of the disease. As a general rule, prolonged treatment was given with daily exposures of 20–30 minutes or in some cases two exposures a day. Large fields were used with an almost continuous current of 1 ma. and a tension of 180 kv. A heavy filtration of 0.7 copper and 2 mm. aluminum was used. An intense erythema is produced. Repeated series of irradiations may be given to prevent later recurrences. The roentgenologist should not hesitate to give intense treatment in these cases, for even though the patients may apparently grow worse for a time there is generally improvement later, particularly cessation of pain, and life may be prolonged for some years.—*Audrey G. Morgan.*

GLOOR, WALTHER, and ZUPPINGER, ADOLF. Blutuntersuchungen bei protrahiert-fraktionierter Bestrahlung. (Blood examinations in protracted fractional irradiation.) *Strahlentherapie*, 1931, *40*, 438–464.

Systematic blood examinations were made in irradiation by the Coutard protracted fractional method; the erythrocyte and hemoglobin values were determined, qualitative and quantitative, white counts made and the serum examined. Brief histories of the 11 cases examined are given. The red blood picture showed slight lability during the treatment but the values rapidly returned to normal after the treatment was finished. The changes in the white blood picture varied, depending on whether there was any pavement epithelium mucous membrane in the irradiated field or not. There was always a slight initial leucocytosis beginning on the 2d to 5th day which was followed immediately or after a few days by a moderate leucopenia which began slowly. With the beginning of the mucous membrane reaction the leucocyte fall was interrupted by another rise that lasted for several days, followed by a fall to the lowest point of the leucocyte curve. This was reached by the time of close of the treatment or a few days later. The variations in the leucocyte curve were caused chiefly by the neutrophil cells. The lymphocytes fell after the beginning of the treatment at first quite rapidly and then gradually to a minimum that was reached by the close of treatment. Recovery was slow. In cases with an unfavorable prognosis they remained permanently low. Monocytes, eosinophils and plasma cells showed only slight changes that were not constant.

In favorable cases the blood values reached normal in from two to four months after the close of treatment. There were no very striking qualitative changes. The occurrence of neutrophil leucocytes with basophil granulation was strictly associated with a skin or mucous membrane reaction. There was occasionally a slight shifting to the left of the leucocyte count. The blood changes were slighter in irradiation with a single large dose rather than greater. Pathological granulation of the neutrophils was caused by absorption of products of disintegration and not by injury of the bone marrow.—*Audrey G. Morgan.*

SUBJECT INDEX TO VOLUME XXVII

(abs) = Abstract (E) = Editorial

Abortion, therapeutic, produced by roentgen rays, 415
Abscess, subphrenic (abs), 790
Absorption, principle of, and method of multiple converging beams, 755
Abyssinia, gastric and duodenal ulcer in black people of (abs), 134
Achondroplasia, two cases of (abs), 648
Acrocephaly (Apert) (abs), 642
Actinomycosis of the kidney (abs), 283
tumor-like, of lung and anterior mediastinum (abs), 629
Adnexa, cancer, early diagnosis (abs), 655
Adrenals, visualization of, on roentgenogram (abs), 794
Agranulocytosis, roentgen treatment of, 40; (abs), 140; (E), 270; 740
treatment (abs), 140
Air pressure, influence of, on formation of erythema and pigmentation of the skin (abs), 476
Amebic granulomas of large bowel (abs), 794
Amenorrhea, temporary roentgen, clinical study (abs), 444
temporary roentgen, exact dosage methods for production of (abs), 475
temporary roentgen, scientific and experimental foundations (abs), 444
American Association for Advancement of Science, Symposium on X-rays and Radium, 905
Radium Society, preliminary program, New Orleans meeting, 608
Roentgen Ray Society, Thirty-third Annual Meeting, preliminary announcement, 905
Anaphylaxis, roentgen, in the normal organism (abs), 460
Aneurysm, aortic, roentgen diagnosis (abs), 786
of pulmonary artery (abs), 632
Angina, agranulocytic: See Agranulocytosis
Angina pectoris, roentgen therapy, 870
Angiopneumography (abs), 914
Aorta, abdominal, recent progress in technique of arteriography of (abs), 649
aneurysm, roentgen diagnosis (abs), 786
descending, tumor-like aspect of ectasia of (abs), 281
roentgen appearance of right-sided arch of (abs), 632
stenosis of, with calcification of the cusps (abs), 787
Aplasia, partial, of right ribs and syndactyly of corresponding hand (abs), 139
Apophyses, persisting, of vertebral column (abs), 918
Apparatus, an absolute high tension electrometer for the practice (abs), 453
description of three practical roentgen timers (abs), 450
mekapion in roentgen therapy (abs), 466
new device for making centered instantaneous roentgen exposures (abs), 450
new instrument for measuring x-radiation (abs), 454
roentgen, disturbances of radiowave reception produced by (abs), 474
simple arrangement for rapid radioscopic-radiographic centering on trochoscope (abs), 473
Appendicitis, chronic, roentgen diagnosis (abs), 638
chronic, roentgen signs (abs), 916
roentgen diagnosis of, and ileocecal perivisceritis (abs), 917
Appendix, active mobility and mechanism of evacuation (abs), 916
pathological, historical development of roentgen diagnosis of, 236
roentgenology of (abs), 132
Arbacia eggs, recovery from roentgen-ray effects, 890
Arteriography, of abdominal aorta, recent progress in technique (abs), 649
Artery, pulmonary, aneurysm of (abs), 632
Arthritis, leprous or tuberculous? (abs), 647
Asbestosis, pulmonary (abs), 783
Asthma, bronchial, roentgen findings in lungs (abs), 911
Atelectasis: See Lungs
Atlanto-axial joint, nontraumatic dislocations of (abs), 646
Avery, O. T., American College of Physicians to award prize to, 427
Azygos lobe: See Lungs

β-rays, secondary, from surface of radium containers (abs), 455
Basedow's disease: See Goiter, exophthalmic
Bianchus, Joannes Baptista, redivivus (E), 423
Bile, an account of manner of efflux and influx (E), 423
Biliary drainage, comparison with cholecystography, in gallstone diagnosis (abs), 637
Biological reaction, modification of, of living tissue to x-radiation, by physical and chemical agents (abs), 471
Bladder, intravenous urography, after Maydl's operation for extrophy of, 103
pathology of malignant neoplasms of (abs), 642
Blood, comparative study of injuries to, by roentgen rays with old method of irradiation and with Metalix protective tubes (abs), 441
diseases, problems of radiotherapy (abs), 144
diseases, roentgen treatment (abs), 440

examinations of, in protracted fractional irradiation (abs), 926
sugar regulation under influence of roentgen rays (abs), 476
BONE, case of fragility of, with cranial deformity and blue sclerae (abs), 648
callus, effect of irradiation of hypophysis on formation of (abs), 452
cystic tuberculosis (abs), 920
fibrosarcoma, rare case (abs), 647
giant cell tumors of, results of roentgen therapy (abs), 146
growth of, and development of rickets (abs), 645
lymphogranulomatous lesions of (abs), 647
marrow, experimental study of action of roentgen rays on (abs), 461
marrow, study of, under action of roentgen rays (abs), 451
metastases (abs), 295
metastases in case of hypertrophic pneumonic osteoarthropathy (abs), 644
repair, plastic, after therapeutic irradiation (abs), 292
sarcoma, results of radiological treatment at Radiumhemmet, Stockholm (abs), 653
syphilis, resembling osteitis deformans (abs), 921
tumors, roentgen diagnosis (abs), 138
BONES, changes in, in reticulo-endotheliosis (abs), 779
irradiated, callus in fracture (abs), 140
long, of hand and foot, peculiar osteoblastic disease in (abs), 139
BOOK REVIEWS
Causation, Diagnosis and Treatment of Cancer. By James Ewing, 121
Radiologie medicala (notiuni pregatitoare si technica generala). By Dimitrie Negru, 122
Wilhelm Conrad Röntgen und die Geschichte der Röntgenstrahlen. By Otto Glasser, 275
Second Annual Reports of the National Radium Trust and Radium Commission, 1930–1931, 275
Zehn Jahre Forschung auf dem physikalisch-medizinschen Grenzgebiet. Edited by Friedrich Dessauer, 429
I sintomi radiologici locali degli stadi di sviluppo dell ulcera duodenale. By G. Martinotti, 429
Esame radiologico dello stomaco e del duodeno. By Alessandro Vallebona, 430
Guide to Radiologic Diagnosis in Heart Disease. Prepared with the aid of the Committee on Research of the Heart Committee. By Geza Nemet, 430
Studies in the Photo-activity and Therapy of the Tungsten-Titanium Arc. By J. Burdon-Cooper and Arthur Roberts, 430
Lehrbuch der Röntgendiagnostik. By H. R. Schinz, W. Baensch and E. Friedl, 618
Röntgenuntersuchungen am innenrelief des Verdauungskanals. By Hans Heinrich Berg, 618
Röntgendiagnostik der Gallenblase. By F. Eisler and G. Kopstein, 619
Die Dickdarmschleimhaus, ihre normale und pathologische Funktion im Röntgenbilde. By Werner Knothe, 619
Surgery of the Chest. By George F. Straub, 619
Électricité et radiologie médicales. By Leon Gally and Pierre Rousseau, 621
A Radiological Study of the Para-nasal Sinuses and Mastoids. By Amedee Granger, 772
Röntgendiagnostik der Erkrankungen inneren Organe in Tabellen und Skizzen. By Emmerich Markovits, 772
Die Röntgendiagnostik der Verdauungs-kanals, einschliesslich der Leber und der Gallenwege. By H. U. Albrecht, 773
Das röntgenographische Bewegungsbild und seine Anwendung. (Flächenkymographie und Kymoskopie). By Pleikart Stumpf, 773
Lehrbuch der Röntgenstereoskopie. By Max Cohn and Walther Barth, 774
Atlas der Röntgenstereoskopie. By Max Cohn, 774
BORDERLINE RAYS, resuscitation of heart by means of (abs), 470
their biological and physical properties and therapeutic application (abs), 465
therapy with, indications and results (abs), 298
BOWEL, large, amebic granulomas of (abs), 794
obstruction in various states of intestinal stasis, value of roentgen evidence (abs), 134
small, obstructive lesions (abs), 792
terminal, sigmoidoscopy versus x-ray in diagnosis of disease of (abs), 636
BRAIN, tumors, incidence of, in epilepsy, as revealed by routine encephalography (abs), 625
tumors, roentgen therapy (abs), 650
BREAST, bleeding, radium treatment (abs), 443
cancer, interstitial irradiation of, with special reference to measured tissue dosage, 547
cancer, interstitial use of gold-filtered radon transfixion tubes in its treatment, 532
cancer, metastases to skeleton, brain and spinal cord and effect of radiotherapy (abs), 651
cancer, occurrence of roentgen pleuropneumonitis in treatment, 509
cancer, postoperative roentgen therapy, 513
cancer, radiotherapy (abs), 300
cancer, roentgen castration as auxiliary to radiotherapy (abs), 147
cancer, treatment of metastatic and inoperable, 517
carcinoma, discussion of symposium on, 556
carcinoma, results of radiation therapy in 1,022 private cases (from 1902–1928), 497
carcinoma, roentgen therapy, statistical study of 977 private cases (abs), 148
etiology of neoplasms of (abs), 142

Bronchiectasis, prognosis in (abs), 911
Bronchography, viscosity of lipiodol in, 847
Bronchoscopy under biplane roentgenoscopic guidance, 225
Bronchospirochetosis in cavities (abs), 630
Burn, gastric, from caustic soda without marked lesions of esophagus (abs), 909
Burns, severe roentgen and radium, method of treatment (abs), 443
Bursa, deep trochanteric, chronic tuberculous hygroma of (abs), 796
subtricipital lithiasis of (abs), 643
Bursitis, subdeltoid, calcified deposits in (abs), 795

Calcemia, investigations on modifications of, in man following radiotherapy (abs), 654
Calcification of gliomas, occurrence of (abs), 626
of intrarenal arteries giving roentgen appearance of calculi (abs), 794
of the cusps and aortic stenosis (abs), 787
Calcifications, pleural, in war veterans (abs), 630
Calcinosis, peritoneal (abs), 132
Calculi, biliary, roentgen visibility of, and vesicular contractions actually observed (abs), 789
vesical, demonstration of, by roentgenography, 97
Callus in fracture of irradiated bones (abs), 140
Cancer, adnexal, early diagnosis (abs), 655
and filaria in the mouse (abs), 464
auxiliary methods in radiotherapy of (abs), 441
concealed, of tongue (abs), 147
development in burn scars (abs), 299
of breast, interstitial irradiation of, with special reference to measured tissue dosage, 547
of breast, interstitial use of gold-filtered radon transfixion tubes in its treatment, 532
of breast, metastases to skeleton, brain and spinal cord, and effect of radiotherapy (abs), 651
of breast, occurrence of roentgen pleuropneumonitis in treatment, 509
of breast, postoperative roentgen therapy, 513
of breast, radiotherapy (abs), 300
of breast, roentgen castration as auxiliary to radiotherapy of (abs), 147
of breast, treatment of metastatic and inoperable, 517
of cervix, combined radium and roentgen treatment (abs), 445
of cervix, technique of radium treatment, 775
of larynx, roentgen and curie therapy of intrinsic and extrinsic (abs), 651
of mouth, radium therapy (abs), 147
of rectum, how far can radium replace radical surgery? (abs), 446
of skin (abs), 652
of stomach, how early do physicians diagnose it in themselves? (abs), 790
of uterus, five-year results of treatment (abs), 444
of uterus, treatment by radiation (abs), 446
organization for fighting, in Baden (abs), 655
post-traumatic (abs), 141
radiation therapy, using subdivided doses (abs), 299
Cancerous tissues, some peculiarities of life of, as evidenced by radiotherapy (abs), 298
Capillary line in pulmonary tuberculosis (abs), 782
Carbon arc light treatment of intestinal tuberculosis, results (abs), 466
Carcinoma, epidermoid, interstitial radiation in metastatic cervical nodes (abs), 146
metastases, roentgen diagnosis of, in lungs (abs), 629
modern methods in treatment (abs), 144
of breast, discussion of symposium on, 556
of breast, results of radiation therapy in 1,022 private cases (from 1902–1928), 497
of breast, roentgen therapy, statistical study of 977 private cases (abs), 148
of cervix, evaluation of high voltage, roentgen rays in therapy of, 877
of cervix, present status of treatment (abs), 448
of cervix, treatment (abs), 445
of esophagus, technique and roentgen findings (abs), 785
of prostate (abs), 448
of rectum (abs), 449
of rectum and colon, difficulties in diagnosis and treatment (abs), 653
of thyroid gland (abs), 908
of thyroid, osseous metastases from (abs), 799
of vulva, clinical experience with (abs), 656
primary bronchogenic, of lungs, 357
primary, of lung (E), 901
primary of lung, roentgen diagnosis and therapy, 858
roentgen treatment (abs), 299
Caries, perforating, of iliac bone, with discharge of intrapelvic abscess into gluteal region (abs), 645
Castration by roentgen rays as auxiliary to radiotherapy in cancer mammae (abs), 147
Cecum, ectopy of (abs), 132
morphology (abs), 793
the erect (abs), 635
Chemical compounds, effect of roentgen radiation on (abs), 471
method for measurement of quantity of radiation (abs), 472
Chest in rachitic children (abs), 627
of children, roentgen re-examination of, six to ten months after measles (abs), 130
Childhood, chronic stridor in, sometimes erroneously attributed to enlargement of thymus (abs), 627
orthodiagraphic evaluation of heart size in (abs), 281

CHILDREN, duration of roentgen visibility of skull fractures in (abs), 125
encephalography in, 686
essential permanent esophagospasm in (abs), 626
evolution of pulmonary tuberculosis in, as revealed by the roentgenogram, 46
experience with encephalography in diseases of nervous system in (abs), 625
rachitic, chest in (abs), 627
roentgen re-examination of chests of, six to ten months after measles (abs), 130
tuberculosis among (abs), 129
tuberculosis in mesenteric lymph nodes of (abs), 639
CHOLECYSTITIS, and biliary lithiasis, roentgen exploration in (abs), 281
CHOLECYSTOGRAPHY, analysis of 500 cases observed by oral method (abs), 636
and Meltzer-Lyon test, comparative results (abs), 133
comparison with biliary drainage, in gallstone diagnosis (abs), 637
peroral, improved method, by giving contrast medium in repeated doses (abs), 637
CHOLESTERIN METABOLISM, relation between roentgen sickness and (abs), 461
CHONDROSARCOMA of fibula (abs), 921
CHORIONEPITHELIOMA of the male (abs), 642
CINCINNATI RADIOLOGICAL SOCIETY, 609
CIRCULATION, intrinsic, of the vertebral body, 818
CO_2, variations of, in relation to Roffo reaction and roentgen rays (abs), 451
COLON, diverticula, and their sequelae (abs), 793
physiology of movements of (abs), 136
studied by double contrast enema, 838
CONNECTIVE TISSUE, pulmonary, experimental investigations on roentgen visualization of (abs), 910
CRANIOSTENOSIS, hereditary familial (abs), 125
CYSTS, congenital, of the lungs (abs), 280
ileocecal (abs), 134
solitary serous renal (abs), 642

DARK-ROOM ILLUMINATION, simplified, 435
DERMATOSES, late injuries after roentgen irradiation of, and conclusions in regard to technique of irradiation (abs), 652
roentgen irradiation of vertebral region in (abs), 442
DIABETES INSIPIDUS and multiple myeloma (abs), 799
DIAPHRAGM, hernia of (abs), 632
postoperative behavior (abs), 631
roentgen study (abs), 788
roentgen study of double and multiple outlines of (abs), 787
DIGESTIVE TRACT: See Gastrointestinal tract
DISLOCATIONS, nontraumatic, of atlanto-axial joint (abs), 646
DIVERTICULA, multiple, of duodenum (abs), 133
of colon and their sequelae (abs), 793
DIVERTICULUM, duodenal, surgically removed (abs), 791
Meckel's (abs), 131
of pericardium, roentgen diagnosis (abs), 632
traction, of esophagus, 187
DOSAGE, measured tissue, interstitial irradiation of mammary cancer with special reference to, 547
x-ray, measurement by physical means (abs), 468
DOSES, erythema and tolerance, in American clinics (abs), 462
"DUODENAL SPOTS" (abs), 791
DUODENUM, abnormal loop form of superior portion of, its differential diagnostic significance (abs), 634
and terminal ileum, hyperplastic tuberculosis of (abs), 634
bulb of, roentgen and differential diagnosis of tumors of (abs), 634
chronic arteriomesenteric stenosis (abs), 791
diverticulum of, surgically removed (abs), 791
morphology of, shown by anatomical and roentgen examination (abs), 131
multiple diverticula of (abs), 133
rare anomaly of (abs), 282
sequels of perforation of ulcer of (abs), 283
ulcer, roentgen differential diagnosis between medical and surgical forms (abs), 791
DUST and pulmonary disease (abs), 628
DYSOSTOSIS cleido-cranialis (abs), 643
craniofacial (abs), 125
cranio-facialis (Crouzon) (abs), 642
DYSTROPHY, case of multiple symmetrical metaepiphyseal juvenile (abs), 795

EBERT'S ASPIRATION DEVICE for testing protection in roentgen departments (abs), 455
ECHINOCOCCOSIS, secondary diffuse pulmonary (abs), 128
EDEMA, acute pulmonary, 101
EFFECT, biological, comparison of, of roentgen and gamma rays (abs), 475
biological, of radiations of different wave length, recent researches (abs), 460
biological, of radium radiation, 1, 14, 18
biological, of roentgen and gamma radiation, immuno-biological and chemical study (abs), 460
of roentgen and ultraviolet rays on reticulo-histiocytic system of the skin (abs), 450
of roentgen radiation on certain chemical compounds (abs), 471
of roentgen rays and radium on eye, 495
of roentgen rays and radium on heart, 149, 303, 479
of roentgen rays on bone marrow (abs), 451; (abs), 461

of roentgen rays on eye (abs), 439
of roentgen rays on time of first cleavage in marine invertebrate eggs, 890
of various amounts of radiation from certain radium preparations upon skin, biological experiments (abs), 475
of various roentgen-ray doses upon mitosis of *Vicia faba equina* (abs), 476
Electrometer, absolute high tension, for the practice (abs), 453
Emboli, pulmonary, distribution of experimental, in roentgenogram (abs), 910
Encephalitis, chronic, roentgen treatment (abs), 300
Encephalography, evaluation of, 657
experience with, in diseases of nervous system in children (abs), 625
in children, 686
indications and contraindications (abs), 625
routine, incidence of brain tumors in epilepsy as revealed by (abs), 625
Enchondroma, case of, and multiple exostoses (abs), 648
Enchondromata, multiple, associated with exostoses in an infant (abs), 291
Enema, double contrast, colon studied by, 838
Enterocolitis, tuberculous, signs of, 65
Eosin, change of color of, produced by roentgen irradiations (abs), 451
Epilepsy, incidence of brain tumors in, as revealed by routine encephalography (abs), 625
Epiphyses of vertebral body, diseases (abs), 918
roentgenographic observations on, 768
Epiphysitis, acute transient, of hip joint (abs), 646
Epithelioma of breast and uterus, bone metastases of, roentgen diagnosis and treatment (abs), 800; (abs), 926
of parotid, recurrence following operation and cured for two years by radiotherapy (abs), 651
Ergosterol, x-ray spectroscopic study of transformation of, in ultraviolet irradiation (abs), 466
Erythema and pigmentation of skin, influence of air pressure on (abs), 476
Esophagospasm, essential permanent, in children (abs), 626
Esophagus, carcinoma, technique and roentgen findings (abs), 785
case of gastric burn from caustic soda without marked lesions of (abs), 909
cicatricial (benign) stricture of, of unknown origin (abs), 627
movements of, roentgenologically demonstrated (abs), 785
partial deglution paralysis as roentgen symptom in diseases of (abs), 908
traction diverticulum of, 187
two cases of varices of, diagnosed by roentgen examination (abs), 280
varices of, roentgen diagnosis, and clinical significance of (abs), 908
Exostoses, a case of multiple, and enchondroma (abs), 648
Exposure time, shortening of, and improvement of processing of roentgen films by use of special after-exposure procedure (abs), 462
Eye, action of roentgen rays and radium on, 495
effect of roentgen rays upon (abs), 439
localization of foreign bodies (abs), 779
tuberculosis of, roentgen treatment (abs), 438

Feet, malformations of, 922
Femur, deformity of head of, following closed reduction of congenital dislocation of hip joint (abs), 292
Fibroma, rhinopharyngeal, roentgen therapy (abs), 301
Fibromas of uterus, penetrating radiotherapy in, and hemorrhages of menopause (abs), 447
Fibromyoma of uterus, radiologic treatment (abs), 447
Fibrosarcoma of bone, rare case of (abs), 647
Fibula, chondrosarcoma of (abs), 921
Filaria and cancer in the mouse (abs), 464
Films, photographic, motion picture and x-ray, safeguarding storage of (abs), 472
Fingers, familial shortening (abs), 921
Fistula, between gall-bladder and duodenum, penetration of opaque paste and air into bile tract in case of (abs), 789
Fistulas, biliary, internal, roentgen diagnosis (abs), 281; (abs), 789
hepatobronchial, roentgen diagnosis (abs), 630
Florida Radiological Society, meeting of, 906
organization of, 120
Foramen of dorsum of the sella, case of (abs), 626
Foreign body, roentgen visibility of glass as, 853
Foreign bodies in lung, localization by roentgen rays, 225
ocular, localization (abs), 779
Fracture of irradiated bones, callus in (abs), 140
of semilunar bone (abs), 798
transverse, of the sacrum (abs), 646
Fractures of mandible, roentgen and legal considerations, 562
of ribs, pleuropulmonary complications (abs), 630
of skull in children, duration of roentgen visibility (abs), 125

Gall-bladder, atonic and strawberry, 205
further observations on its function (abs), 461
roentgen evaluation of anomalies and variations (abs), 134
roentgen visibility of calculi, and vesicular contractions actually observed (abs), 789
visualization in jaundiced patients (abs), 637
Gangrene, arthritic, in a diabetic, treated by irradiation of suprarenal region (abs), 302
Gastrointestinal tract, comparative pathologico-anatomic and roentgen studies of diseases of (abs), 633

observation on motility of, in starving rats (abs), 452
roentgen examination of, in chronic lead poisoning (abs), 131
GAUCHER'S DISEASE, splenectomy in (abs), 141
GENITAL GLANDS, external injuries of, not caused by roentgen rays (abs), 148
GENITALIA, female, results in roentgen treatment of inflammatory lesions of (abs), 446
GENITOURINARY TRACT, tumors, radiation therapy (abs), 148
GLASS, roentgenographic study of, and its visibility as foreign body, 853
GLIOMAS, occurrence of calcification in (abs), 626
GLYCEMIA, investigations of modifications of, in man, following radiotherapy (abs), 654
GOITER, exophthalmic, and virile and nonpuerperal osteomalacia (abs), 798
intrathoracic, with severe stenosis of esophagus and trachea cured by roentgen rays (abs), 924
size and shape of heart in (abs), 787
toxic, roentgen therapy (abs), 300
GRENZ RAYS: See Borderline rays
GYNECOLOGY, radium in (abs), 444

HANDS, malformations of (abs), 922
HAY FEVER, treatment by radiotherapy (abs), 302
HEART, action of roentgen rays and radium upon, 149, 303, 479
and chest, mensuration of, in left posteroanterior oblique position, 177, 363, 585, 729
determination of size and position of various parts, by means of surface kymogram (abs), 787
determination of type of enlargement (right or left), 363
disease of, clinical and roentgen examination of lung in (abs), 786
effects of gamma rays and short x-rays upon (abs), 298
instantaneous roentgenography of, at 3 meter 50 cm. distance (abs), 459
orthodiagraphic evaluation of size of, in childhood (abs), 281
relation of its transverse diameter to the thorax, 177
resuscitation of, by means of soft roentgen rays after it had stopped beating on account of removal of its permeable potassium salts (abs), 470
size and shape of, in goiter (abs), 787
HEMANGIOMA of larynx, radium treatment (abs), 443
results of radiation therapy, 249
HEMATOMA, infected intraperitoneal, diagnosed by roentgen examination (abs), 282
HEMOPATHIES and roentgen rays (abs), 144
radiotherapy (abs), 143
HEPATOGRAPHY (E), 604
following injection of thorium dioxide sol (thorotrast), 53
HEPATO-SPLENOGRAPHY (abs), 640
HERNIA, diaphragmatic (abs), 632
pulmonary, of the right apex, rare case of (abs), 780
HEUBLEIN, ARTHUR C., obituary (E), 764
portrait of, 764
HICKEY, PRESTON M., presentation of plaque to University of Michigan in memory of (E), 109
HIP JOINT, acute transient epiphysitis of (abs), 646
HISTORICAL DEVELOPMENT of roentgen diagnosis of pathological appendix, 236
of roentgen exploration of gall-bladder (abs), 281
HODGKIN'S DISEASE, aleucemic and leucemic lymphoblastoma and mycosis fungoides, genetic neoplastic relationships (abs), 296
involvement of bone in (abs), 647
pathogenesis, radiotherapy and prognosis (abs), 652
HOLZKNECHT, GUIDO, obituary notice (E), 114
portrait of, 114
HUMERUS, cystic disease of, complicated by primary myelogenous sarcoma (abs), 922
osteogenic sarcoma of (abs), 139
HYDATID DISEASE in England (abs), 923
HYDATIDIFORM MOLE, injection of lipiodol in uterine cavity in, 899
HYGROMA, chronic tuberculous, of deep trochanteric bursa (abs), 796
HYPOPHYSIS, effect of irradiation of, on formation of bone callus (abs), 452

ILEOCECUM, cysts of (abs), 134
ILIAC BONE, perforating caries of (abs), 645
INDIANA ROENTGEN SOCIETY, 609
INDUCTION COIL, high voltage, and cascade tube roentgen-ray outfit, 405
INFANT THORAX, roentgen examination, 610
INFLAMMATION of interlobar pleura, roentgen appearance (abs), 784
INFLAMMATORY conditions, radiotherapy for (abs), 439
diseases of female genitalia, results of roentgen treatment (abs), 446
INJURIES, late, after roentgen irradiation of dermatoses and conclusions in regard to technique of irradiation (abs), 652
late, from roentgen rays (abs), 299
INTENSITY of radium radiations, relation of, to tissue reaction, 1
INTERNATIONAL COMPARISON of roentgen-ray units, 884
INTERVERTEBRAL DISC (abs), 798
extensions into vertebral bodies and spinal canal (abs), 796
INTESTINE, acute obstruction (abs), 633
large, amebic granulomas of (abs), 794

obstruction, acute, elaboration of criteria upon which early diagnosis may be made(abs), 791
obstructive lesions of (abs), 792
polyposis, roentgen examination (abs), 794
Intrathoracic affections, profile roentgen examination for localization of (abs), 631
Intussusception, colo-colic, from adenomatous polyp (abs), 794
subacute and chronic intestinal, roentgenologic aspect, 373
Iodipin used for visualization of joints (abs), 295
Ionization of air in roentgen rooms (abs), 456
Ionometric studies on additional dose of scattering (abs), 473
Iron miners, pneumoconiosis in (abs), 628
Irradiation of pathological tissues, divergences between anticipated and observed results of, 14
protracted fractional, blood examinations in (abs), 926
therapeutic, plastic bone repair after (abs), 292

Jaches, Leopold, honored, 274
Jaundice, gall-bladder visualization in patients with (abs), 637
Jejunum, roentgen study of movements of (abs), 282
Joints, visualization of, by means of iodipin filling (abs), 295

Kidney, actinomycosis of (abs), 283
an original method of estimating function of, by means of roentgen ray in intravenous urography, 234
calcification of intrarenal arteries giving roentgen appearance of calculi (abs), 794
clogged, roentgen findings in case of (abs), 285
pathology of tumors of (abs), 284
solitary, serous cysts of (abs), 642
ureter, anomalies (abs), 642
Kienböck's disease (abs), 647
Klippel-Feil's syndrome, case of (abs), 924
Köhler's disease, tuberculosis and (abs), 291
Kümmell's disease (abs), 293
Kymogram, determination of size and position of various parts of heart by means of (abs), 787

Larynx, hemangioma of, radium treatment (abs), 443
intrinsic and extrinsic cancers of, roentgen and curie therapy (abs), 651
Lead poisoning, chronic, roentgen examination of gastrointestinal tract in (abs), 131
shadows produced by, in roentgenograms of growing skeleton (abs), 290
Leucocytosis, recurrent, in blood of a radiologist (abs), 296
Lienography (E), 604
following injection of thorium dioxide sol (thorotrast), 53
Light, effects of, on skin (abs), 463
Linitis and gastric calcification (abs), 915
Lipiodol, injection of, in uterine cavity in hydatidiform mole, 899
viscosity of, in bronchography, 847
Lipoma, unusually located, complicated by a foreign body, 267
Lithiasis, biliary, in combination with puzzling renal affections (abs), 132
subtricipital, of the bursa (abs), 643
Lithopedion, life history of, 262
Liver: See also Hepatography
examination of, by contrast medium (abs), 788
roentgen visualization of, in the human, 265
Lumbarization of first sacral vertebra (abs), 645
Lung, site of predilection in cross-infection from right to left (abs), 126
Lungs, acute edema of, 101
arteries and veins in, roentgen visibility (abs), 914
atelectasis, postoperative (abs), 784
auxiliary lobe of azygos vein (abs), 788
azygos lobe, cases of pathologic (abs), 910
azygos lobe, hereditary character (abs), 909
azygos lobe, interlobar pleurisy of (abs), 784
azygos lobe, new observations (abs), 280
basal paramediastinal triangular shadows (abs). 788
bronchospirochetosis in cavities (abs), 630
changes in position of fissures of, and of lung hila in fibrotic processes (abs), 782
clinical and roentgen examination of, in heart disease (abs), 786
congenital cysts of (abs), 280
connective tissue in, experimental investigations on roentgen visualization (abs), 910
differential diagnosis between tuberculosis and malignant neoplasms (abs), 127
distribution of experimental pulmonary emboli in roentgenograms (abs), 910
dust and disease of (abs), 628
dust and roentgen appearance of, in stone workers (abs), 628
findings in, in lymphogranulomatosis (abs), 280
frequency of accessory lobe of azygos vein, in systematic examinations for drafting for the army (abs), 909
knowledge of lymph vessels of (abs), 126
localization of foreign bodies in, by roentgen examination, 225
miliary disease of, due to unknown cause, 337
obstructive collapse (abs), 909
postoperative hypoventilation (abs), 629
primary bronchogenic carcinoma, 357
primary carcinoma (E), 901
primary carcinoma, roentgen diagnosis and therapy, 858
rare case of hernia of right apex (abs), 780
roentgen aspects of scissura and azygos lobe in pulmonary tuberculosis (abs), 910

roentgen diagnosis of carcinoma metastases in (abs), 629
roentgen findings in, in bronchial asthma (abs), 911
roentgenography of discrete lesions of (abs), 279
roentgenography of, with tube with rotating anode (abs), 474
sclerosis, roentgen signs (abs), 782
secondary diffuse echinococcosis of (abs), 128
shadow formations in upper fields of (abs), 911
some unusual pneumonias associated with aspiration of fats and oils in, 572
syphilis, frequency, pathology and roentgen appearance (abs), 913
syphilis, roentgen aspects (abs), 912
test grid for exposures of, and limit of roentgen visualization of finer tuberculous foci (abs), 912
tumor-like actinomycosis of, and anterior mediastinum (abs), 629
upper medial portions, roentgenology of (abs), 911
LYMPH nodes, mesenteric, in children, tuberculosis of (abs), 639
vessels of lung, knowledge of (abs), 126
LYMPHATIC DRAINAGE, demonstration of, from maxillary sinuses, 352
LYMPHOBLASTOMA, aleucemic and leucemic, Hodgkin's disease and mycosis fungoides, genetic neoplastic relationships (abs), 296
LYMPHOGRANULOMATOSIS, importance of roentgen rays in diagnosis (abs), 141
case of, cured for four years (abs), 439
lung findings in (abs), 280
roentgen irradiation of (abs), 440
visceral (abs), 449
LYMPHOSARCOMA, pathogenesis, radiotherapy and prognosis (abs), 652
radiosensibility of (abs), 461

MANDIBLE, fractures, roentgen and legal considerations, 562
MAYDL'S OPERATION for extrophy of bladder, intravenous urography after, 103
MEASLES, roentgen re-examination of chests of children six to ten months after (abs), 130
MEASUREMENT of quantity of radiation, chemical method for (abs), 455
of quantum energy of x-rays, new method for (abs), 472
of tensions of tube and apparatus (abs), 455
of x-radiation, new instrument for (abs), 454
of x-ray dosage by physical means (abs), 468
MEASUREMENTS, lead absorption, with extremely hard roentgen rays (abs), 466
water phantom intensity, of roentgen rays produced by 127,000 volts, 749
MEDIASTINUM, differential diagnosis of tumors of (abs), 128
MEDULLOBLASTOMA, roentgen therapy (abs), 650
MEKAPION in roentgen therapy (abs), 466
MELORHEOSTOSIS, case of (abs), 293
MELTZER-LYON TEST, and cholecystography, comparative results (abs), 133
MENINGIOMAS of convexity of brain, anatomic and radiologic aspects (abs), 279
MENINGOCELE, Billroth's traumatic spurious, roentgen study of two cases of (abs), 286
MENOPAUSE, hemorrhages of, penetrating radiotherapy in (abs), 447
MESENTERIUM ILEO-COLICUM COMMUNE, roentgen and differential diagnosis (abs), 635
METALIX PROTECTIVE TUBES, study of injuries to blood by roentgen rays with old method of irradiation and with Metalix protective tubes (abs), 441
METAPHYSES of long bones, some structures found in spongiosa of (abs), 293
METASTASES, bone (abs), 295
bone, from epithelioma of breast and uterus, roentgen diagnosis and treatment (abs), 800; (abs), 926
intracranial carcinomatous (abs), 125
osseous, of thyroid neoplasm (abs), 799
to skeleton, brain and spinal cord from cancer of breast, effect of radiotherapy (abs), 651
METATARSAL BONES, fracture of, simulating thromboangiitis obliterans (abs), 292
METHYLENE BLUE, experiments with, on dog, with reference to study of function of gallbladder (abs), 461
MILLIAMMETERS, ordinary, how far can they be used for reading short-time currents? (abs), 471
MINNESOTA RADIOLOGICAL SOCIETY, 427
MITOSIS of *Vicia faba equina*, effect of various roentgen doses on (abs), 476
MOUTH, radium therapy of cancer of (abs), 147
MUCOSA, gastric, simple procedure for studying folds of (abs), 915
MYCOSIS FUNGOIDES, Hodgkin's disease and aleucemic and leucemic lymphoblastoma, genetic neoplastic relationships (abs), 296
MYELOGRAPHY with skiodan (abs), 795
MYELOMA, multiple (abs), 295
multiple, and diabetes insipidus (abs), 799
plasma-cell, roentgen study of skeletal changes in (abs), 648

NECROSES, aseptic, of skeleton, pathogenesis (abs), 647
NEOPLASMS, malignant, of bladder, pathology (abs), 642
malignant, palliative therapy (abs), 301
malignant, pulmonary or bronchial, differential diagnosis between, and pulmonary tuberculosis (abs), 127
of breast, etiology (abs), 142
NERVOUS SYSTEM in children, experience with encephalography in diseases of (abs), 625
NEUTRAL RED SALVE of Roffo in treatment of

wounds, ulcers and cleansing of tumors (abs), 451
Niche in the diagnosis of jejunal ulcer, 59
Nucleus pulposus, new case of calcified (abs), 919

Obstetrics, radiology in (abs), 283
roentgen ray as an adjunct in diagnosis (abs), 136
Occupational diseases, extension of law on (abs), 142
Offspring, injurious effects of roentgen rays upon (abs), 299
Orthoradiographic device (abs), 474
Ossification, accessory centers of, in dorsal spinal column (abs), 645
Osteitis condensans of unknown etiology and multiple localizations (abs), 648
Osteoarthropathy, hypertrophic pneumonic, bone metastases in case of (abs), 644
Osteoblastic disease, peculiar, in long bones of hand and foot (abs), 139
Osteochondritis dissecans, résumé of theories of etiology and consideration of heredity as etiologic factor (abs), 920
Osteomalacia, lunate (abs), 647
virile and nonpuerperal, and Basedow's disease (abs), 798
Osteopoikilosis, 580; (abs), 799
anatomic findings in case of (abs), 917
Ostosis, eburnizing monomelic (melorheostosis), case of (abs), 293

Palpation, danger of, with unprotected hand (abs), 456
Palsy, bulbar, roentgen findings in chronic progressive, 717
Paralysis, partial deglutition, as roentgen symptom in diseases of esophagus (abs), 908
Paralysis, unilateral, of the pharynx (abs), 780
Parotid, epithelioma, recurrence following operation and cured for two years by radiotherapy (abs), 651
Patella, tuberculosis, clinical and roentgen diagnosis (abs), 646
Pediatrics, emergency value of roentgen therapy in (abs), 297
Pellegrini-Stieda's disease (abs), 922
evolutive and stabilized forms (abs), 921
Pelvimetry, roentgen-ray, a simplified stereoroentgenographic method, 83
Pelvis, measurement of, and problem of lateral pelvic roentgenography (abs), 463
Pericardium, diverticulum, roentgen diagnosis (abs), 632
Peritoneum, calcinosis of (abs), 132
Perivisceritis, ileocecal, roentgen contribution to diagnosis of appendicitis and (abs), 917
Pharynx, unilateral paralysis of (abs), 780
Phosphorus, effect of radon upon distribution of, in body of angiostomized dogs (abs), 470
Pituitary gland, tumors, interpretation of roentgenograms of, 697
Pleura, calcifications of, in war veterans (abs), 630
interlobar, roentgen appearance of inflammation (abs), 784
Pleural effusions in tumor, roentgen characteristics (abs), 785
Pleurisy, exudative carcinomatous or sarcomatous, roentgen treatment (abs), 441
interlobar, of azygos vein lobe (abs), 784
Pleuropneumonitis, roentgen, occurrence of, in treatment of breast cancer, 509
Pneumoconiosis, delayed development of symptoms (abs), 783
in iron miners (abs), 628
Pneumonias, some unusual, associated with aspiration of fats and oils in the lungs, 572
Pneumothorax, spontaneous (abs), 130; (abs), 629
Pneumoventriculography, evaluation of, 657
Polyp, adenomatous, case of colo-colic intussusception from (abs), 794
Polyposis, intestinal, roentgen examination (abs), 794
Potassium, value in radiobiology (abs), 465
Projections in relief (abs), 474
Prostate, carcinoma of (abs), 448
Protection in roentgen departments, use of Ebert's aspiration device for testing (abs), 455
radiation, rules for, in medico-roentgen institutes (abs), 470
Psoriasis, ten years' experience in irradiation of thymus in its treatment (abs), 650
Pyelography: See also Urography
intravenous (abs), 137; (abs) 138; (abs), 641
intravenous, value with uroselectan in roentgen examination of kidney and its pelvis (abs), 137
with uroselectan (abs), 641
Pyloric muscle in adults, hypertrophy (abs), 635
Pylorus, diagnostic value of prepyloric and pyloric roentgen findings, 193

Quantum energy of x-rays, new method of measuring it (abs), 455

Radiation, distribution of, around radium tubes (abs), 465
grouping of radium tubes in packs or plaques to produce desired distribution of, 18
penetrating, in the atmosphere (abs), 470
quantity of, chemical method for measurement of (abs), 472
roentgen and gamma, immunobiological and chemical study of biological action of (abs), 460
Radiations of different wave length, recent researches on biological action of (abs), 460
Radio wave reception, disturbances of, produced by roentgen apparatus (abs), 474
Radiobiology, value of potassium in (abs), 465

RADIOLOGICAL SECTION, Los Angeles County Medical Association, new officers, 274
RADIOLOGIST, recurrent leucocytosis in blood of (abs), 296
RADIOLOGY, INSTITUTE OF (University of Cluj) (abs), 471
RADIUM containers, secondary β-rays from surface of (abs), 455
emanation, new therapeutic indications of (abs), 447
in treatment, experimental use of large quantity (abs), 301
needles, small, versus radon implants, 240
preparations, methods for testing, used by physical laboratory of Radiumhemmet, Stockholm (abs), 453
radiations, relation of intensity, to tissue reaction, using segment of growing mouse tail as biological indicator, 1
therapy, in institutes at Paris (abs), 145
tubes, distribution of radiation around (abs), 465
tubes, grouping in packs or plaques to produce desired distribution of radiation, 18
RADON implants, small radium needles versus, 240
implantation, endoscopic, 362
its effect upon distribution of phosphorus in body of angiostomized dogs (abs), 470
transfixion tubes, gold-filtered, interstitial use of, in treatment of mammary cancer, 532
RECTIFICATION, thermionic, of x-ray circuits (abs), 453
valve, advantages of (abs), 454
RECTIFYING VALVES, emission of roentgen rays by (abs), 453
RECTUM, and colon, difficulties in diagnosis and treatment of carcinoma of (abs), 653
cancer of, how far can radium replace radical surgery? (abs), 446
carcinoma of (abs), 449
RELIEF, projections in (abs), 474
RETICULO-ENDOTHELIOSIS, changes in bones in (abs), 779
RETICULO-HISTIOCYTIC SYSTEM of the skin, action of roentgen and ultraviolet rays on (abs), 450
R[illegible]EONARD, obituary notice (E), 271
RIBS fractures, pleuropulmonary complications (abs), 630
RICKETS, development of, and growth of bone (abs), 645
in children, chest in (abs), 627
ROENTGEN circuits, thermionic rectification (abs), 453
department of Hospital of University of Michigan, 770
departments, use of Ebert's aspiration device for testing protection in (abs), 455
exposures, instantaneous, new device for making centered (abs), 450
films, as property of physician, 906
films, methods and appliances for rapid examination of, 432
films, storage problem, moral and physical aspects of (abs), 457
films, why they should be preserved indefinitely (abs), 458
irradiation, change of color of eosin produced by (abs), 451
irradiation, microchemical and cytologic findings in plant tissues after (abs), 451
irradiation, study of action of, on bone marrow (abs), 451
outfit, high voltage induction coil and cascade tube, 405
radiation, new instrument for measuring (abs), 454
rooms, ionization of air in (abs), 456
sickness, relation between cholesterin metabolism and (abs), 461
therapy, emergency, value in pediatrics (abs), 297
therapy, mekapion in (abs), 466
therapy, using principle of absorption and method of multiple converging beams, 755
tubes, self-protecting, and their influence on development of roentgen technique (abs), 467
units, international comparison, 884
ROENTGEN RAYS, and radium, symposium on, American Association for the Advancement of Science, program, 905
blood sugar regulation under influence of (abs), 476
emission of, by rectifying valves (abs), 453
extremely hard, lead absorption measurements with (abs), 466
high voltage, in therapy of carcinoma of cervix, 877
local by- and after-effects (abs), 925
produced by 127,000 volts, water phantom intensity measurements of, 749
quantum energy, new methods of measuring it (abs), 455
ROENTGENOGRAMS, ownership of, 120; 906
ROENTGENOGRAPHY, instantaneous, of the heart at 3 meter 50 cm. distance (abs), 459
lateral pelvic, and pelvic measurements (abs), 463
of lungs, with tube with rotating anode (abs), 474
ROENTGENOLOGY in medical service (abs), 142
ROENTGENOSCOPIC-ROENTGENOGRAPHIC CENTERING, simple arrangement for rapid, on the trochoscope (abs), 473
ROFFO REACTION and roentgen rays, variations of CO_2 in relation to (abs), 451

SACRUM, transverse fracture of (abs), 646
SARCOID, roentgen changes in, and related lesions (abs), 296

Sarcoma of bone, results of radiological treatment at Radiumhemmet, Stockholm (abs), 653
osteogenic, of humerus (abs), 139
primary myelogenous, complicating cystic disease of humerus (abs), 922
undifferentiated round-cell (abs), 301
Scars, burn, development of cancer (abs), 299
Scattering, ionometric studies on additional dose of (abs), 473
Sclerosis, pulmonary, roentgen signs (abs), 782
Screens, intensifying, effect of technique on speed of (abs), 472
Sella turcica, case of foramen of dorsum of (abs), 626
Semilunar bone, fracture (abs), 798
Shoulder joint, some misformations in (abs), 921
Sialography (E), 763
Sigmoidoscopy versus x-rays in diagnosis of terminal bowel disease (abs), 636
Silicosis, pulmonary, diagnosis (abs), 783
Sinuses, maxillary, demonstration of lymphatic drainage from, 352
sphenoid, roentgen morphology, studied with contrast medium (abs), 626
Skeleton, changes in, in plasma-cell myeloma, roentgen study (abs), 648
growing, shadows produced by lead in roentgenogram of (abs), 290
pathogenesis of aseptic necroses of (abs), 647
Skin, action of roentgen and ultraviolet rays on reticulo-histiocytic system of (abs), 450
biological experiments on effect of various amounts of radiation from certain radium preparations upon (abs), 475
effects of light on (abs), 463
influence of air pressure on formation of erythema and pigmentation of (abs), 476
malignancy of (abs), 652
Skiodan, myelography with (abs), 795
Skull, fractures of, in children, duration of roentgen visibility (abs), 125
xanthomatosis with defects in bones of (abs), 779
Spine, abnormalities of the vertebral body, 801
comparative examination on pathology and roentgenology of (abs), 918
diseases of epiphyses of vertebral body (abs), 918
dorsal, accessory centers of ossification in (abs), 645
intrinsic circulation of the vertebral body, 818
new case of calcified nucleus pulposus (abs), 919
persisting apophyses of (abs), 918
roentgen signs of tuberculosis of vertebral body, 827
Spleen: See also Lienography
examination of, by contrast medium (abs), 788
roentgen visualization of, in the human, 265
roentgenologic anatomy and physiology of (abs), 639
Splenectomy in Gaucher's disease (abs), 141
Spondylitis traumatica tarda (Kümmell's disease) (abs), 293
Stasis, intestinal, value of roentgen evidence of bowel obstruction in (abs), 134
Stenosis, aortic, with calcification of the cusps (abs), 787
chronic arterio-mesenteric, of duodenum (abs), 791
Stereoroentgenography, a critique of, 257
Stomach, and duodenum, roentgen treatment of ulcer of (abs), 653
burn from caustic soda, without marked lesions of the esophagus (abs), 909
calcification and linitis plastica (abs), 915
cancer, how early do physicians diagnose it in themselves? (abs), 790
mucosal folds, simple procedure for studying (abs), 915
operated, roentgen symptomatology of (abs), 915
relief, visualization in supine position (abs), 915
study of motility of (abs), 633
syphilis of, roentgen diagnosis (abs), 634
tuberculosis, some cases studied roentgenologically (abs), 133
varices of, roentgen diagnosis and their clinical significance (abs), 908
volvulus of, 420
Stone workers, roentgen appearance of dust lung in (abs), 628
Stricture, cicatricial (benign) of esophagus of unknown origin (abs), 627
Stridor, chronic, in childhood, sometimes erroneously attributed to enlargement of the thymus (abs), 627
Strobograph, roentgen-ray, wave form analysis by means of, 105
Styloid process of ulna, its form, anomalies, fractures and triangular bone of wrist (abs), 644
Suprarenal region, arthritic gangrene in a diabetic treated by irradiation of (abs), 302
Supraspinatus tendon, pathology associat[illegible] with rupture of (abs), 294
Surgery, thoracic, contrast media roentgenography in, 720
Syndactyly of right hand, and partial aplasia of right ribs (abs), 139
Syphilis, congenital osseous, roentgenographic and pathologic aspects (abs), 286; (abs), 288; (abs), 290
gastric, roentgen diagnosis (abs), 634
of bone resembling osteitis deformans (abs), 921
pulmonary, frequency, pathology and roentgen appearance (abs), 913
pulmonary, roentgen aspects (abs), 912
roentgen appearance of some bone and joint changes in (abs), 795

TABETIC CRISES, roentgen treatment (abs), 442
TECHNIQUE, effect of, on speed of intensifying screens (abs), 472
on the profile roentgen examination for localization of intrathoracic affections (abs), 631
TENSIONS of tube and apparatus, measurement of (abs), 455
TETRAIODOPHENOLPHTHALEIN, sodium, paths of absorption and excretion of (abs), 135
THALLIUM, experimental effects of, on rats and mice (abs), 460
THORAX, contrast media roentgenography in surgery of, 720
infant, roentgen examination, 610
THOROTRAST, hepatography and lienography following injection of, 53
THYMOMA, diagnosis of (abs), 128
THYMUS, observations on (abs), 128
ten years' experience in its irradiation in psoriasis (abs), 650
THYROID, carcinoma of (abs), 908
carcinoma, osseous metastases from (abs), 799
TIME CONTROL in medical roentgen service (abs), 450
TISSUE, living, modification of biological reaction of, to x-radiations, by physical and chemical agents (abs), 471
reaction, relation of intensity of radium radiations to, 1
TISSUES, pathological, divergences between anticipated and observed results of irradiation of, 14
TONGUE, cancer, concealed, (abs), 147
TROCHOSCOPE, simple arrangement for rapid radioscopic-radiographic centering on (abs), 473
TUBERCULOSIS, acute generalized, without typical tubercles (abs), 127
among children (abs), 129
and Köhler's disease (abs), 291
atypical, simulating lung metastases (abs), 781
chronic miliary of the lungs, and its relation to theory of Ranke (abs), 781
cystic, of bone (abs), 920
hyperplastic, of duodenum and terminal ileum (abs), 634
in mesenteric lymph nodes in children (abs), 639
intestinal, results of carbon arc light treatment of (abs), 466
intestinal, signs of, 65
of bone, joint and bursa, diagnostic inaccuracy (abs), 796
of eye, roentgen treatment (abs), 438
of patella, clinical and roentgen diagnosis (abs), 646
of stomach, some cases studied roentgenologically (abs), 133
of vertebral body, roentgen signs, 827
pulmonary, capillary line in (abs), 782
pulmonary, differential diagnosis between, and pulmonary or bronchial malignant neoplasms (abs), 127
pulmonary, diffuse, bilateral, with small discrete lesions associated with tuberculous laryngitis (abs), 628
pulmonary, evolution in children as revealed by the roentgenogram, 46
pulmonary, nonapical infiltrations in (abs), 126
pulmonary, roentgen appearance of forms of, associated with surgical tuberculosis (abs), 627
pulmonary, roentgen aspects of scissura and azygos lobe in (abs), 910
pumonary, roentgen prognosis (abs), 781
pulmonary, study of position of primary cavities in (abs), 912
roentgen record file in combating (abs), 780
roentgen visualization of finer foci in (abs), 912
study of, in one junior high school in Honolulu (abs), 912
TUMORS, bone, roentgen diagnosis (abs), 138
brain, incidence of, in epilepsy, as revealed by routine encephalography (abs), 625
brain, roentgen therapy (abs), 650
extra-alimentary, roentgenology, 383
giant-cell of bone, results in roentgen therapy (abs), 146
internal malignant, difficulties in radiotherapy (abs), 652
intracranial (abs), 125
mediastinal, differential diagnosis (abs), 128
of duodenal bulb, roentgen and differential diagnosis (abs), 634
of genitourinary tract, radiation therapy (abs), 148
of urinary tract (abs), 284
pituitary, interpretation of roentgenograms of, 697
renal, pathology of (abs), 284
roentgen characteristics of pleural effusions in (abs), 785

ULCER, closed perforating, manifesting itself by subhepatic gas bubble (abs), 790
duodenal, sequels of perforation (abs), 283
gastric and duodenal in black people of Abyssinia (abs), 134
jejunal, niche in the diagnosis of, 59
of duodenum, roentgen differential diagnosis between medical and surgical forms (abs), 791
of stomach and duodenum, roentgen treatment (abs), 653
ULNA, styloid process of (abs), 644
ULTRAVIOLET irradiation, x-ray spectroscopic study on transformation of ergosterol in (abs), 466
UNIVERSITY OF MICHIGAN, x-ray unit of hospital of, 770
URINARY TRACT, tumors of (abs), 284
UROGRAPHY: See also Pyelography
intravenous, after Maydl's operation for extrophy of the urinary bladder, 103

intravenous, an original method of estimating kidney function by means of roentgen ray in, 234
uroselectan intravenous (abs), 136
Uroselectan, intravenous urography with (abs), 136; (abs), 137
on the retention of (abs), 285
pyelography with (abs), 641
report on, by Council on Pharmacy and Chemistry of the American Medical Association (abs), 641
Uterus, cancer of, five-year results of treatment (abs), 444
cancer of, treatment by radiation (abs), 446
cervix, cancer, combined radium and roentgen treatment (abs), 445
cervix, cancer, technique of radium treatment, 775
cervix, carcinoma, evaluation of high voltage roentgen rays in therapy of, 877
cervix, carcinoma, present status of treatment (abs), 448
cervix, carcinoma, treatment (abs), 445
fibroma, penetrating radiotherapy in, and hemorrhages of menopause (abs), 447
fibromyoma, radiologic treatment (abs), 447

Veins, visualization in roentgenogram by means of contrast medium (abs), 923
Ventriculography: See also Pneumoventriculography
indications and contraindications (abs), 625
method of (abs), 625
Vertebra, first dorsal, persistence of accessory centers of ossification in (abs), 645
first sacral, lumbarization of (abs), 645
four cases of supernumerary sixth lumbar (abs), 139
sixth lumbar, painful hemisacralization of (abs), 294
Vertebral body, abnormalities, 801
diseases of epiphysis of (abs), 918
intrinsic circulation of, 818
roentgen signs of tuberculosis of, 827
Vertebral region, roentgen irradiation of, in some dermatoses (abs), 443
Vicia faba, difference between "natural death" and roentgen-ray death of root points of (abs), 451
equina, effect of various roentgen doses upon mitosis of (abs), 476
Viscosity of lipiodol in bronchography, 847
Volvulus of the stomach, 420
Vulva, carcinoma, clinical experience with (abs), 656

Wave form analysis by means of roentgen-ray strobograph, 105
Wounds, ulcers, etc., neutral red salve of Roffo in treatment of (abs), 451

Xanthomatosis, with defects in the cranial bones (abs), 779

AUTHOR INDEX TO VOLUME XXVII

Adair, Frank E., 517
Adams, W. E., 909
Adson, Alfred W., 657, 716
Agati, Dino, 283
Ahlbom, Hugo, 147
Airale, Giovanni, 128
Akerson, Irving B., 294
Albrecht, H. U., 773
Allen, Kenneth D. A., 631
Allen-Price, E. D., 921
Almeida Lima, 914
Alvarez, Walter C., 790
Ané, J. N., 452
Anspach, Brooke M., 655
Anzilotti, Alberto, 131, 791
Arapoff, Anna, 470
Arendt, J., 642, 787
Arlabosse, J., 648
Arnell, S., 795
Arnone, G., 782
Arvanitakis, G., 279
Asti, Mario Luigi, 137
Aubertin, Charles, 296
Azmy, S., 420

Bach, Mark J., 799
Bäcklin, Erik, 466
Badgley, Carl E., 827
Baensch, W., 618
Bagg, Halsey J., 1
Bagliani, Mario, 629
Bagnaresi, Giacomo, 132
Balestra, Giovanni, 635
Banci-Buonamici, C., 451
Barringer, Benjamin S., 448
Bársony, Theodor, 782, 911
Barth, Walther, 774
Bastian, G., 133
Batson, O. V., 835
Baumann, H., 787, 788
Baumann, R., 460
Becker, Rudolf, 136
Beer, Edwin, 136
Behney, Charles A., 877, 883
Behr, F., 921
Bell, G. Eric, 453
Belot, J., 651
Benassi, E., 626
Benhamou, 639
Benner, Sven, 455
Berg, Hans Heinrich, 618
Bergsma, Stuart, 134
Bergstrand, Hilding, 139
Berkheiser, E. J., 646
Bermond, Marco, 139
Betoulières, 909
Bianchi, Giovanni, 286
Bianchini, A., 632
Biedermann, Fritz, 632
Bignami, G., 143, 283, 798
Bilger, F., 132
Billich, H. U., 440
Bistolfi, S., 630
Blackberg, S. N., 452
Blaine, Edward S., 293, 647
Bloch, E., 924
Bloch, Robert G., 847
Bockus, H. L., 637
Bödecker, 780
Bøggild, David, 641
Böhmig, R., 918
Bolin, Zera E., 127
Bonanno, Antonio M., 786
Bönniger, M., 912
Bonta, Maurice B., 141
Borman, C., 134
Borsotti, P. C., 626
Bouwers, A., 467
Bowen, David R., 610
Bowie, E. R., 870
Boyden, Edward A., 424
Braasch, William F., 641
Braestrup, C. B., 105
Brailsford, James F., 923
Braun, R., 475
Brdiczka, J. G., 634
Britton, James A., 783
Brodin, 638
Bromberg, Leon, 921
Bromer, Ralph S., 627, 836
Brown, A. Lincoln, 784
Brown, C. R., 472
Brown, Samuel, 788
Brunet, R., 302
Brunetti, Lodovico, 787
Brunschwig, A., 103
Buckstein, Jacob, 59, 236
Buisson, Paola, 789
Bumpus, Hermon C., Jr., 641
Burdon-Cooper, J., 430
Burnam, Curtis F., 446
Businco, Ottavio, 910

Caldas, P., 649
Camentron, 630
Cameron, William H., 560
Camp, John D., 770
Campbell, D., 642
Camplani, Mario, 647
Cannavo, L., 630
Cappelli, Luigi, 460
Cardia, Antonio, 910
Careddu, Giovanni, 795
Carhart, E. C., 234
Carlson, H. A., 134
Carr, Walter Lester, 128
Carty, John R., 471
Casati, Annibale, 461, 466, 782, 791
Casazza, Roberto, 795
Castellino, Pietro G., 450
Castronovo, Ettore, 125
Caylor, Harold D., 642
Chadwick, Henry G., 46
Chantraine, Enrico, 474
Charpy, P., 474
Chérigié, 654
Cherry, Homer H., 65, 129
Christian, Henry A., 787
Christie, Arthur C., 717
Clausing, Arthur, 474
Clerc, 281
Clerf, Louis H., 874
Codman, Ernest A., 294
Coe, Fred O., 101
Cohen, Bernard N. E., 920
Cohn, Max, 643, 774
Cola, G., 630
Colaneri, 449
Cole, L. G., 126
Cole, W. C., 126
Coley, William B., 295
Conte, Ettore, 460
Cook, Carol E., 912
Cookson, Harold, 787
Coolidge, W. D., 405
Copeland, Murray M., 295
Cottet, P., 291
Cotton, Albertus, 350
Crane, A. W., 110
Czerny, L. I., 650

D'Amato, Giuseppe, 293
Dahm, Max, 785
Damm, E., 285
Danelius, Gerhard, 911
Darbois, 912
Dausset, 919
Dautwitz, Fritz, 443
Deery, Edwin M., 625
Degiorgi, H., 451
Del Buono, Pietro, 779
Delario, A. J., 135
Demel, R., 923
Dempster, L. E., 405
Denier, 302
Desjardins, A. U., 149, 281, 303, 439, 477, 495, 755
Desplats, 654
Dessauer, Friedrich, 429
Dethmers, A., 280
Dioclès, 474
Dobrovolskaia-Zavadskaia, N., 464

Doherty, W. D., 790
Donaldson, S. W., 562, 571, 836
Doolittle, S. E., 912
Dorrance, George M., 559
dos Santos, Reynoldo, 649
Doub, Howard P., 827, 837
Downes, Helen R., 472
Drennen, Earle, 134
Dufour, Pierre, 789
Duggan, LeRoy B., 921
Dunhill, T. P., 908
Duval, 799
Dvorak, H. J., 134

Egas Moniz, 914
Eichbaum, Franz, 629
Einhorn, Max, 53
Eisenhardt, Louise, 125
Eisler, F., 619
Eley, R. Cannon, 686
Emmert, Fred, 262
Evans, William A., 570, 801, 905
Ewing, James, 121, 556

Failla, G., 247, 414, 454, 468, 761, 889
Faulkner, D. M., 291
Fay, Temple, 712
Feenstra, T. P., 470
Feldman, Maurice, 636
Ferrata, Adolfo, 144
Fike, R. H., 509
Findlay, Leonard, 911
Firor, Whitmer B., 140, 740, 748
Fischel, Karl, 126
Fisk, George W., 794
Fitz-Hugh, Thomas, Jr., 747
Flecker, H., 769
Fliederbaum, J., 648
Floris, Michele, 446
Foa, A., 626, 648, 794
Fontaine, R., 132
Forsberg, R., 779
Forsdike, Sidney, 444
Frain, 281
Frangella, Alfonso C., 447
Frank, Josef, 452
Fray, Walter W., 177, 363, 585, 729
Freid, Jacob R., 651
Freund, Ernst, 292
Freund, Leopold, 298
Friedl, E., 618
Frimann-Dahl, J., 779
Frothingham, Channing, 127
Fuhs, H., 652
Fürst, Walter, 441

Gabriel, Gerhard, 298
Gager, Leslie T., 40
Galland, R., 628
Gally, Leon, 621, 638
Garcin, Joseph, 133
Gard, Raymond L., 632
Gardner, J. E., 628
Garin, Ch., 783
Garvin, John D., 634
Gauss, C. J., 444
Gavrilescu, Stelian G., 922
Geist, Emil S., 798
Gendreau, J. E., 298
Gershon-Cohen, J., 838
Gilbert, 909
Gill, A. Bruce, 834
Glasser, Otto, 39, 117, 275, 462
Gloor, Walther, 926
Goalwin, Harry A., 779
Gordon-Watson, Charles, 446
Gotten, Nicholas, 625
Gräberger, Gösta, 281, 282, 645, 788, 789
Graham, Allen, 284
Graham, Stanley, 911
Gram, H. C., 466
Granger, Amedee, 772
Graninger, Karl, 443
Gröninger, J., 915
Grosglik, Adam, 652
Grunspan-de Brancas, Mathilde, 283
Guében, Georges, 465
Gunn, Herbert, 794
Gunsett, A., 473, 651
Gurd, Fraser B., 144
Gutman, René A., 915

Haam, Emmerich, 265
Habs, Hubert, 456
Haeger, Ernst, 462
Hallock, Leonard A., 794
Halpert, Béla, 461
Halter, C. Robert, 1
Hamburger, Louis P., 140
Hanke, Milton T., 461
Harbin, R. M., 131
Haret, 281, 799
Harmon, Paul H., 922
Harris, William, 415
Hayden, E. Parker, 449
Hayer, E., 300, 652, 915
Heacock, C. H., 792
Head, Jerome R., 783
Headland, C. I., 126
Healy, William P., 445
Heckenbach, W., 285
Hedblom, Carl A., 720
Heeren, I., 441
Heinismann, J. I., 650
Held, A., 476, 781
Henline, Roy B., 642
Henshaw, P. S., 890
Herbst, Robert, 642
Herendeen, Ralph E., 146, 558
Heritage, Kenneth, 137
Herpel, Frederick K., 120
Herrmann, Heinrich, 466
Heyman, James, 445
Hirsch, Henri, 441
Hirschboeck, Frank J., 130
Hjelm, R., 280
Hodges, Paul C., 83, 96
Hodgson, H. Graham, 793
Holfelder, Hans, 925
Holmes, George W., 349, 873
Hosoi, Kiyoski, 128
Howard, Nelson J., 794
Hummel, Rudolf, 461
Hunt, Verne C., 283

Ichok, G., 142
Illick, H. Earl, 53
Illig, Werner, 125
Imbert, René, 915
Isaacs, Raphael, 270
Ivy, R. H., 569
Izkovitch, I., 142

Jackson, Deborah, 290
Jackson, W. P., 628
Jacquet, Paul, 638
Jaeger, Robert, 466
Jalet, J., 909, 910
Janker, Robert, 918
Jansson, Gösta, 632
Jaubert de Beaujeu, A., 459, 631, 924
Joly, Marcel, 647
Judson, Herbert A., 97
Jüngling, O., 476

Kadrnka, Silvije, 640, 643
Kajdi, Laslo, 290
Kaplan, Ira I., 297, 559, 616
Kegerreis, Roy, 912
Kennedy, Roger L. J., 627
Kidd, Frank, 137
Kirklin, B. R., 296, 874
Kirsch, Oskar, 281
Kleinschmidt, O., 299
Knoll, W., 295
Knothe, Werner, 619
Knutsson, Folke, 790
Ko Muro-Hide o, 451
Kobozieff, N., 464
Kohn, Jerome L., 130
Koiransky, Henry, 130
Kollert, V., 923
Konrad, Josef, 652
Koppenstein, Ernst, 782, 911
Kopstein, G., 619, 646

Kotschneff, Nina, 470
Krebs, Carl, 461
Kremser, Curt, 442
Kryński, A., 443

La Field, W. A., 765
Lachmann, Ernst, 781
Lamarque, 909
Lamas, C., 649
Lambranzi, Mario, 301
Landau, W., 628
Langendorff, H., 476
Langeron, 654
Lapidus, Paul W., 292
Laquerrière, A., 644
Larimore, Joseph W., 132, 383
Laroche, Albert, 138
Laroche, Guy, 638
Laschi, Gino, 626
Lau, Frederick T., 642
Lawson, George B., 628
Lazarus-Barlow, W. S., 301
Le Bourdellès, B., 910
Ledoux, Alfred C., 83
Ledoux, E., 291
Lee, Burton J., 547, 560
Lehman, E. Burton, 265
Lehmann, Robert, 644
Lenz, Maurice, 651
Leonard, Marion, 639
Levene, George, 435
Levin, Isaac, 652
Levy, D. M., 465
Levyn, Lester, 271
LeWald, L. T., 634
Lewis, Raymond W., 853
Lewishon, Richard, 58
Lidström, F., 795
Litten, F., 794
Livingstone, H. M., 909
Loben, Franz, 280
Lochry, Ralph L., 899
Lockhart-Mummery, J. P., 793
Lopo de Carvalho, 914
Lorey, A., 438
Lovisatti, Nicola, 140, 793, 794
Lynch, F. W., 134
Lynch, Kenneth M., 783
Lyon, Ernst, 918

Macchioro, Gino, 139
McClure, C. C., 635
MacFee, William F., 147
McIntyre, Mary C., 913
McKenna, Hugh, 922
McLean, Stafford, 286, 288, 290
Magnusson, W., 653
Maino, Mario, 781
Mandeville, F. B., 650
Manges, Willis F., 95, 577, 858, 875
Marchioni, 639
Marey, Ahmed, 420
Markovits, Emmerich, 772
Markuszewiez, R., 648
Martin, Charles L., 240, 241
Martin, Florence J., 795
Martinotti, G., 429
Marum, Gottlieb, 918
Mascherpa, Fermo, 799
Masson, Clement B., 626
Matthews, Harvey B., 136
Matthies, Th., 295
Mattina, M., 782
Mayo, Charles 2nd, 283
Meagher, Richard, 125
Meisels, Emil L., 798
Meldolesi, Gastone, 800, 926
Meller, Oskar, 126, 910
Ménégaux, G., 651
Menkes, B., 910
Menville, Leon J., 452
Meriwether, F. V., 337
Mesz, N., 648
Middleton, William S., 799
Milgram, Joseph E., 796
Miller, Oscar Lee, 292, 646
Mitchell, Edward C., 645
Møller, P. Flemming, 466
Moore, Sherwood, 432
Morse, R. W., 126
Morton, Charles B., 139
Morton, S. A., 296
Müller, Erich H., 450
Mumford, E. B., 795
Muresanu, E., 646
Murphy, Douglas P., 13
Murphy, John T., 112
Mutscheller, A., 455
Mylius, K., 438

Nadaud, P., 648
Naz, Edouard, 643
Neale, A. Victor, 921
Nebout, J., 633
Neeff, Th. C., 475
Negru, Dimitrie, 122, 471
Neill, William, Jr., 560
Nelson, H. P., 788
Nelson, Martha V., 645
Nemet, Geza, 430
Nemours-Auguste, 915
New, G. B., 627
Nichols, B. H., 284
Niemann, Carl, 455
Nourettine, C., 473
Novy, Frederick G., 112
Nurnberger, L., 299

Oppenheimer, Albert, 136, 916
Otell, Laurence S., 101
Ottonello, Pietro, 465, 780
Overholt, Richard H., 629

Pack, George T., 299, 532
Paget, 654
Palmer, J. P., 629
Pancoast, Henry K., 225, 348, 357, 557, 570, 578, 615, 697, 719, 883
Pansdorf, Hans, 300
Pareuti, Silvio, 780
Park, Edwards A., 290
Parkhurst, Howard J., 463
Parkinson, John, 787
Parry, Leo D., 148
Pendergrass, Eugene P., 225, 357, 576, 625, 818
Perotti, Desiderio, 132
Pessel, J. F., 637
Petrignani, Roger, 921
Pfahler, George E., 148, 263, 352, 497, 560, 571
Pfeiffer, Damon B., 558
Phemister, Dallas B., 301
Picarda, J., 917
Piergrossi, Aldo, 293
Pierson, John W., 572, 579, 715
Piot, Etienne, 917
Pirie, A. Howard, 349, 578
Pohlandt, Klaus, 634
Politzer, G., 922
Pomeranz, Maurice M., 138
Popp, Leonida, 909
Portmann, U. V., 148, 462, 513
Pound, R. E., 126
Prévôt, R., 918
Profitlich, P., 473

Quéméré, 654
Quick, Douglas, 17, 146
Quimby, Edith H., 18, 472

Rabinowitsch, A. M., 128
Rask-Nielsen, Hans C., 461
Ratti, Arduino, 785
Rautereau, R., 628
Ravdin, I. S., 58
Regaud, Cl., 298, 300
Reilly, William A., 127
Reisner, A., 475
Reiter, Michael, 463
Remy, Charles E., 457
Remy-Roux, 447
Renander, Axel, 133, 644
Reynolds, Lawrence, 604, 763, 901
Robb, Charles, 749
Roesler, Hugo, 249
Roffo, A. H., 141, 444, 451
Rohrschneider, W., 439

Ronneaux, 638
Rossi, Armando, 205
Rossi, Vittorio, 795
Rousseau, Pierre, 621
Rowlands, R. P., 790
Rudisill, Hillyer, 637
Ruggles, Howard E., 193
Russell, Albert E., 628
Ruthven, Alexander G., 133

St. Graur, Emil, 447
Salotti, Adelchi, 282
Saltzstein, Harry C., 653
Sametnik, S., 633
Samuel, E. C., 870
Sandera, Robert, 635
Sandström, Carl, 637
Sandweiss, David J., 653
Sante, L. R., 262, 264, 349
Santoro, Angelo, 145, 147
Santoro, Mario, 791
Sarles, Roger, 133
Sashin, David, 796
Satta, F., 645, 647, 796
Saupe, Erich, 280
Sayers, R. R., 337, 350
Schall, W. E., 454
Schatzki, R., 908
Schechtmann, J., 455, 456
Schilling, C., 633, 788
Schinz, H. R., 618
Schmidt-Labaume, F., 476
Schmidtlein, Ernst, 916
Schmorl, G., 917
Schulze, Walter M. H., 470
Schwartz, G., 648
Schwentker, Francis F., 920
Seidler, Ferdinand, 646
Seifert, E., 921
Sgalitzer, M., 923
Shapiro, Louis L., 187
Shay, Harry, 637, 838
Shedden, William M., 449
Sichler, Harper G., 786
Siciliano, L., 144, 440, 451
Sievert, Rolf M., 453, 455
Sighinolfi, Piero, 625
Simon, George, 788
Simon, R., 103
Simpson, Frank E., 443, 775
Sinistrero, Cesare, 645
Smith, William A., 783
Smithies, Frank, 633
Sobel, 912
Sosman, M. C., 263, 714
Speer, Alma Jane, 40
Speierer, Carl, 650
Spillman, Ramsey, 458, 615
Spinnelli, A., 452
Squirru, C. M., 451
Stein, Arthur, 128
Stenstrom, Wilhelm, 471
Stevens, R. H., 652
Stewart, F. Constance, 128
Stewart, Fred W., 14
Stewart, William H., 53
Stieve, H., 148
Stone, Robert S., 193
Straub, George F., 619
Stuhl, L., 279
Stumpf, Pleikart, 773
Sturtevant, Mills, 187
Surmont, J., 281
Sussman, Marcy L., 373
Sweany, Henry C., 257, 912
Swindells, Frank E., 472

Taft, Robert B., 629
Talia, 452
Talia, F., 294, 630, 924
Talini, Pier Carlo, 785
Tanis, H. E., Jr., 405
Tartagli, Dino, 130, 473
Tausch, M., 656
Taylor, Howard C., Jr., 142
Taylor, Lauriston S., 884, 889
Temel, Tarik, 647
ten Doornkaat-Koolman, Menna, 439
Thoraeus, Robert, 471
Torek, Franz, 128
Tourne, W., 285
Tracy, F. E., 650
Trautmann, Edgar, 300
Treves, Norman, 299
Tripoli, Carlo J., 265
Tucker, Gabriel, 225, 357, 577
Turano, Luigi, 784

Uhlmann, E., 476
Ullmann, H. J., 13
Uspensky, A., 141

Vallebona, Alessandro, 430
Van Hazel, Willard, 720
Viallet, 639
Vinson, Porter P., 627
Viola, Carolina, 625
Vittori, Domenico, 784
Vogt, Edward C., 686
v. Friedrich, L., 790
von Lichtenberg, A., 641
v. Pannewitz, G., 908
Vynalek, William J., 642

Wagoner, George, 818, 837, 920
Wahl, H. R., 632
Wallace, Robert P., 187
Walton, Henry J., 95, 349
Walzel, P., 134
Wangensteen, O. H., 134, 791
Warthin, Aldred S., 296
Waters, Charles A., 140, 740
Weatherwax, J. L., 39, 749
Weiss, Konrad, 647
Weiss, Kurt, 655
Weitzner, Imre, 267
Wejdling, Knut, 466
Wiese, H. W., 383
Wiewiorowski, 780
Wilcox, Leslie F., 580
Wilhelmy, E., 450
Willard, J. H., 637
Wintz, Hermann, 444
Wolodkewitsch, N., 450
Wood, Francis Carter, 301
Wright, R. S., 453

Yeomans, Frank C., 636

Zdansky, Erich, 911
Zimmern, A., 279, 302
Zuppinger, Adolf, 926
Zwaardemaker, H., 470
Zweifel, Erwin, 448

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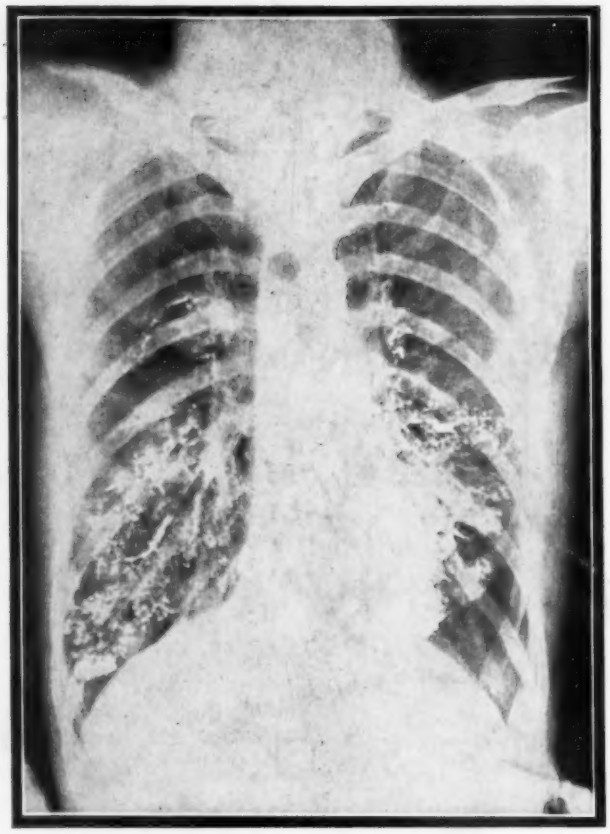

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